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THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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A Remarkable Textbook

Barber's First Course in General Science

By FREDERICK D. BARBER, Professor of Physics in the Illinois State Normal University, MERTON L. FULLER, Lecturer on Meteorology in the Bradley Polytechnic Institute, JOHN L. PRICER, Professor of Biology in the Illinois State Normal University, and HOWARD W. ADAMS, Professor of Chemistry in the same. vii+588 pp. of text. 12mo. $1.25.

A recent notable endorsement of this book occurred in Minneapolis. A Committee on General Science, representing each High School in the city, was asked to outline a course in Science for first year High School. After making the outline they considered the textbook situation. In this regard, the Committee reports as follows:

"We feel that, in Science, a book for first year High School use should be simple in language, should begin without presupposing too much knowledge on the part of the student, should have an abundance of good pictures and plen[illegible] of material to choose from.

Barber's *First Course in General Science* seems to us to be[illegible] meet these requirements and in addition it suggests materials for home experiments requiring no unusual apparatus, and requires no scientific measurements during the course. We recommend its adoption."

Other Interesting Opinions on the Book Follow:

SCHOOL SCIENCE AND MATHEMATICS:—It is one of the very best books on general science that have ever been published. The biological as well as the physical side of the subject is treated with great fairness. There is more material in the text than can be well used in one year's work on the subject. This is, however, a good fault, as it gives the instructor a wide range of subjects. The book is written in a style which will at once command not only the attention of the teacher, but that of the pupil as well. It is interesting from cover to cover. Many new and ingenious features are presented. The drawings and halftones have been selected for the purpose of illustrating points in the text, as well as for the purpose of attracting the pupil and holding his attention. There are 375 of these illustrations. There is no end to the good things which might be said concerning this volume, and the advice of the writer to any school board about to adopt a text in general science is to become thoroughly familiar with this book before making a final decision.

WALTER BARR, *Keokuk, Iowa*:—Today when I showed Barber's Science to the manager and department heads of the Mississippi River Power Co., including probably the best engineers of America possible to assemble accidentally as a group, the exclamation around the table was: "If we only could have had a book like this when we were in school." Something similar in my own mind caused me to determine to give the book to my own son altho he is in only the eighth grade.

G. M. WILSON, *Iowa State College*:—I have not been particularly favorable to the general science idea, but I am satisfied now that this was due to the kind of texts which came to my attention and the way it happened to be handled in places where I had knowledge of its teaching. I am satisfied that Professor Barber, in this volume, has the work started on the right idea. It is meant to be useful, practical material closely connected with explanation of every day affairs. It seems to me an unusual contribution along this line. It will mean, of course, that others will follow, and that we may hope to have general science work put on such a practical basis that it will win a permanent place in the schools.

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THE SCIENTIFIC MONTHLY

NOVEMBER, 1917

BACTERIOLOGY AND THE WAR[1]

By Dr. DAVID JOHN DAVIS,
PROFESSOR OF PATHOLOGY AND BACTERIOLOGY OF THE UNIVERSITY OF ILLINOIS

THERE are so many aspects of this problem that it is somewhat difficult to determine where to begin and what to discuss. The war is so vast in its influence and bacteriology is so extensive in its scope that naturally they come into contact at many points. It shall not be my purpose, though it would be quite to the point, to discuss the great fields of agricultural bacteriology, industrial bacteriology, plant bacteriology and veterinary bacteriology. These all have a more or less intimate relationship with the war. I shall limit myself to that phase of the subject that concerns the prevention and cure of human affliction.

Nor shall I condescend to discuss the possible uses that deadly disease-producing germs may be put to in the willful destruction of human or animal life, highly suggestive reports of which have recently come to our attention. Even in war such practises are so repellent to every sense of honor and fair play that it is difficult to believe them in this twentieth century of Christian civilization.

The relation of bacteriology and war is a reciprocal one. While the study of bacteria has most fundamentally affected the success and the methods of procedure in military campaigns, in turn, there is presented to the bacteriologist for solution many new problems of vital interest to the science. Not only are new fields for investigation opened up by the war, but military organization furnishes opportunities for observation and confirmation of existing data on a scale and under conditions not usually possible in civil life.

During the war, the destruction of life by disease-producing germs often, indeed usually in the past, has far exceeded the

[1] Address delivered at the Opening Exercises of the University of Illinois, College of Medicine, Chicago, October 4, 1917.

destruction of life by bullets. We have only to point to the Spanish-American War less than twenty years ago to appreciate the truth of this statement. We may naturally anticipate therefore that in the present world war, the rôle that these minute creatures play will be one of first importance.

War, and especially the present war, involves the congregating and mingling of great bodies of men, frequently from distant parts of the world. This means the transportation of human and animal parasites along with the hosts. This transportation of parasitic varieties of animal or plant life we have long known to be a dangerous process. As examples, we may mention the Mexican cotton-boll weevil, the gipsy moth, and the foot and mouth virus. The bestowal by the white man upon the Indian of tuberculosis, syphilis, measles and smallpox along with culture and enlightenment has nearly cost the latter his existence as a race. In general, parasites transported to a new soil commonly increase their ravages enormously. This is one of the phenomena observed in connection with this war, examples of which will be cited presently.

The ravages of disease germs in the army may not be the most serious phase of this problem. The return of the troops to their homes—of the wounded during the war, and the entire army after the war—must lead to a more general infection of the civil population with the various diseases that commonly follow the military camps.

I shall now refer rather briefly to certain infectious, bacterial diseases which may serve to illustrate some of the more important advances for which the war, to some degree at least, is responsible. In general this progress naturally centers round studies dealing with the etiology and specific therapy of these infections.

Trench Fever.—An unusually interesting disease has made its appearance especially on the west front, to which the term trench fever has been given. This appeared shortly after the beginning of the war and was first definitely recognized and carefully described by Rankin in 1915. It has occurred especially in Flanders, France and England; also in Mesopotamia, the Balkans, Saloniki, among the Austrian and German troops on the eastern front and in the Tyrol.

Trench fever is not a good name, for it is known to occur in England and attacks often many persons who have never been to the trenches. It occurs virtually in epidemic form, thousands of persons at times rapidly coming down with the infection. It is different from any hitherto known disease. It is a definite clinical entity and is no doubt infectious in nature.

There is a typical fever curve, often relapsing in character, intense and constant shin pains, persisting often for months, and an increase in the mononuclear leucocytes, the total count usually being, in the febrile stage, 14,000 to 16,000. One attack does not confer immunity. It is never fatal, but causes often great suffering and distress and interferes seriously with the efficiency of the troops. No doubt our American troops in France will soon be infected, since it appears to be highly contagious.

The cause of the disease is entirely unknown, as is also its mode of transmission. Experiments on volunteers indicate that the disease can be reproduced by injecting blood from a patient into well persons and also that the virus resides in the blood corpuscles and not in the serum. Thus far no visible parasite has been detected in the blood. Trench fever has been less troublesome in the troops who have had good bathing facilities and who have in general been cleanest. Active campaigns against lice seem to have lessened the incidence of the disease. Captain Urquhard acquired the short form of the disease after permitting lice from a patient suffering with this disease to bite him. Lice are so common under present war conditions that practically every one is infested, and hence a history of pediculosis means little in determining transmission. At present it is not surely known whether or not lice are the usual or the natural agents in the transmission of this disease; they are, however, under strong suspicion.

One naturally asks whence comes such a disease. So far as we know it is an entirely new infection. Did it arise *de novo* as it were, by a sudden appearance of a mutant from some related virus? The discovery of its etiology may throw light on this problem, but as yet all attempts to find its cause have failed. Possibly this infection has existed unrecognized in some remote corner of the world and by the mobilization of various races in this world war it has found conditions suitable for its rapid spread.

Infectious organisms, no doubt, originate as do other species, but bacteriologists as yet have never observed an infectious disease arise. Is the disease of trench fever an instance of such a new infection? If this should be the case it might furnish a unique opportunity for the study of the ultimate origin of a disease. And after this trench warfare is over and the troops have scattered again to the corners of the earth, what will be the fate of this new disease? We shall watch this phenomenon with interest.

Infectious Jaundice.—Infectious jaundice appears to be a

common disease often occurring more or less in epidemic form. The cause of the jaundice seems to be varied. A certain proportion of the cases are no doubt intestinal in origin and caused by organisms of the paratyphoid group.

But another infection has been recognized which is now known to certainly cause a very considerable number of these icteric cases. It is commonly referred to as Weil's disease. This disease is not new, having been observed in previous wars; possibly it was responsible for many of the 70,000 cases of jaundice which occurred in our Civil War. It is characterized by intense muscular pains, high fever for several days, followed by jaundice and nephritic changes in the urine. Often intense hemorrhages under the skin and from the nose occur.

This disease is caused by a spirochete, the *Spirocheta icterohemorrhagiae*, which has now been repeatedly found in the various fluids and organs of the infected persons. It appears especially in large numbers in the kidneys and urine, as well as in the liver of the host. Most interesting are the observations recently made, particularly by Japanese investigators, that this germ commonly infects the wild rat, which may harbor it for a long time without special harm to itself. The kidneys of the rat likewise contain large numbers of the spirochetes and they are thrown out in the urine of the animal to infect the soil, and especially the water. Trenches would therefore furnish an excellent place for the dissemination of this disease. From the soil and water the organisms find their way into the human body both through the skin of the feet and into the intestinal canal. This disease has now been recognized along the entire western front. It is rarer in Belgium and France, but appears to be quite common along the Italian line. It prevails in the German armies and has attacked the British soldiers at Saloniki. In Japan the disease exists in a highly virulent form, especially among miners and rice planters who go barefoot. Work so far done along therapeutic and immunologic lines gives promise of success, but it is early as yet to make definite assertions on these points.

This disease is another example of an important human infection transmitted largely if not entirely by a lower animal and is also another severe indictment against that king of pests, the wild rat. Recently Noguchi has found this same spirochete in the kidneys of wild rats in New York city. Its dissemination probably has been quite general though not in large numbers. No doubt the war will tend to spread the disease still further and probably to cause a more universal infection of rats with the specific germ.

Trench Nephritis.—Trench nephritis is an exceedingly common disease on the various fronts, and, though much work has been done with the view of determining its cause, the real nature of the malady remains obscure. It manifests itself as an acute process and certain features of the disease suggest its possible infectious nature. Some of the cases at least may be infections with the spirochete of Weil's disease. Pathologically and clinically the disease closely resembles the form of nephritis seen following colds, scarlet fever, etc. No specific microbe has as yet been isolated and attempts to transmit the disease have failed.

Cerebrospinal Fever.—Cerebrospinal fever has long been known to be an army disease, though now it has come to be a serious menace in both peace and war times. It appears to affect soldiers living in camps, barracks, towns, etc., rather more than those engaged in an active campaign. During the present war it has occurred particularly in England, and early attacked especially the Canadian troops when quartered in that country. The disease during the past season broke out in several of our recruiting camps. As the summer advanced, the disease gradually subsided; excepting an occasional focus, there is little at the present time. However, unless radical measures are taken next winter and spring, we may predict to almost a certainty a recurrence of serious outbreaks of this highly dangerous malady.

Its cause, the meningococcus, finds its normal habitat in the nose and throat of human beings. Now and then it passes through the mucous membranes into the blood and lymph streams, finding its way into the region of the brain, especially the meninges, where it grows and produces an acute inflammation. By no means do all who harbor the germs in their nasopharynx develop the disease, but such "carriers" serve as dangerous reservoirs for the dissemination of the bacteria to others who may be susceptible. Naturally then the campaign against this infection consists in the proper treatment of "carriers," both healthy and sick, as well as in the curative treatment of those ill with the disease.

The war has furnished and is furnishing an excellent opportunity for a severe test on a large scale of methods of control and treatment which had been devised largely before the war. With reference to the serum treatment of the disease, perfected several years ago in the United States by Flexner, a large body of data tended to show the undoubted value of the intraspinal injection of serum as manufactured by the Rockefeller Institute. Some time before the war this institution

ceased making the serum, turning this work over to various public health and commercial laboratories.

In the winter of 1914–15 on the continent, especially in England, many cases of meningitis developed in both the civil and military population. Though the patients were promptly given the serum that was available, the death rate continued abnormally high, ranging 50 to 60 per cent. or even higher. The death rate in earlier epidemics in this country, when the Rockefeller serum was used, had been from 20 to 30 per cent. On investigation it was found that the trouble no doubt lay in the poor quality of the serum available at the beginning of the war. Since then the Rockefeller Institute has resumed its manufacture of the serum and other reliable laboratories here and abroad have also taken up the work with the result that during the past year the mortality of this disease in Europe and also in the United States Army compares with the earlier data, that is, 20 to 30 per cent. mortality. The serum should be made by the injection into horses of several strains of meningococcus, it being now definitely recognized that there exist a number of groups of these germs differing at least to some degree, especially in their immunologic properties.

As to the "carriers," especially those who are healthy or who show no definite symptoms of meningitis, considerable progress has been made in their management. The healthy "carrier" is more dangerous than the person ill with the disease. They outnumber the latter 10 to 30, or more, to one. Any individual coming into intimate contact with a meningitis patient is practically sure to become a "carrier." A nurse or a mother tending her sick child is certain sooner or later to contain the meningococcus in her naso-pharynx. The recognition of such persons is made possible by wholesale culturing on suitable media of entire bodies of troops and others coming in contact with them, and those harboring the germs are isolated and treated. The treatment is various. The germs may disappear in time without any special therapy. Often they are very persistent and resist most vigorous treatment. Tonsilectomy has been resorted to with little success. Encouraging results have been obtained by the vigorous use of nasal and throat sprays. For this purpose various antiseptics have been tried, but those most efficient seem to be 2 per cent. chloramin-T and zinc sulphate, 1.2 per cent. in watery solution.

It is to be emphasized that there is a real and serious danger from this highly fatal disease in the mobilization of troops from various parts of the country. However, we now know enough to quite successfully cope with it, provided we apply

what we know. The successful preventive measures include a careful survey of localities from which the men come with reference to meningitis, a systematic search for "carriers" and their retention until free from meningococcus; early diagnosis and isolation with repeated intraspinal injections of a reliable serum. To keep the disease out of a camp, every soldier should be examined for meningococci before he is allowed to enter the barracks.

Typhoid Fever.—Were one discussing this subject of infectious disease in almost any other war in history, the larger part of the time would be devoted to intestinal infections, especially typhoid fever. In this war, thanks largely to protective vaccination, the so-called enteric fevers have ceased to be a serious problem. Our knowledge of the dissemination of typhoid through carriers and of the methods for their detection is also a most important phase of the control of this disease.

The development of the use of vaccines in this disease during the last fifteen years must be counted as one of the great medical achievements of the age, and ranks beside Jenner's discovery of smallpox vaccination. This procedure used in the United States Army and elsewhere before the war and now submitted to the crucial test of protecting the huge armies in this war under most varied and critical circumstances has now, it would seem, demonstrated its value in a way which should convince the most skeptical. What further proof is necessary to show that now typhoid fever or at least a large part of it in our country and elsewhere is entirely unnecessary. The problem has been solved from the standpoint of scientific medicine. It is now a public health and social problem. In other words it is squarely "up to the people" as to whether or not they wish to use what the contributions of medical science have given them.

Paratyphoid fever, a disease simulating typhoid, but less fatal, has been a serious infection in certain regions. This was largely because proper vaccination was not resorted to, for example, in the Gallipoli campaign. The experience of the war, however, has confirmed the results, obtained on a limited scale before the war, that vaccination with paratyphoid bacilli is as efficacious in preventing this disease as is the procedure in typhoid fever. Often vaccines are administered composed of mixtures of typhoid bacilli and paratyphoid, A and B, and in the eastern front, the cholera bacillus is also added. The injection of mixtures of these varieties of dead bacteria has been found to immunize satisfactorily and saves much time.

Asiatic Cholera.—Asiatic cholera naturally has, in the east

where it is more or less endemic, been responsible for many cases of sickness, but great epidemics have not developed. The problem here is almost identical with that of typhoid and paratyphoid fevers. Vaccination with dead or treated cholera vibrios, the detection of "carriers," and proper control of water and food supplies are the procedures which will make Asiatic cholera as little feared by the soldiers as is smallpox.

The *Dysenteries* are in a less satisfactory state than the typhoid fevers. Especially in the eastern and Mediterranean campaigns both amebic and bacillary types of the disease have been very prevalent. No serious outbreaks have occurred on the western front. Extensive and valuable studies, especially of the protozoal varieties, have been made by the Medical Research Committee of Britain and our knowledge of them has been greatly extended. Vaccination has not proved of great value in this disease, probably because of the high toxicity of the bodies of the bacilli. The problem of "carriers" is here paramount and through proper hygienic precautions satisfactory progress is being made in the control of this disease. In amebic dysentery we have a very effective therapeutic agent, emetine, the favorable results obtained heretofore having been abundantly confirmed on an extensive scale in the military camps of the Mediterranean countries. Emetine given subcutaneously, while practically curing the disease, does not sterilize the intestinal canal and such individuals often become chronic "carriers" of amebæ. Dale and others have used a new compound, emetine bismuth iodide, by the mouth and have found it more effective in completely sterilizing the patient of his amebæ. Oral administration is therefore likely to supplant the hypodermic use of emetine in this infection.

Wound Infections.—Wound infections of all kinds have of course appeared in this war on a scale never before met with in the history of medicine. With these the bacteriologist and the surgeon have contended valiantly and on the whole hopeful progress has been achieved. The nature of the warfare makes primary disinfection of the wounds usually impossible and often suppuration is well advanced before the patient reaches the surgeon. The pyogenic cocci, fecal bacteria and especially the anaerobes are the chief offending organisms.

In the management of these cases, the medical men have, as it were, arranged themselves into two schools. First, those who rely chiefly upon the physiological mechanisms in the body to combat and resist the invading germs and, second, those who depend on the application from without of antiseptic substances to kill or prevent development of germ life.

Sir A. E. Wright, known to the world for his studies in pathology, especially in phagocytosis, has well been called "the apostle of physiological methods." Wright, during this war and close to the front, has done splendid work in the field of surgical bacteriology. He has devised methods for drawing into the infected areas the fluids of the body containing the protective substances normally found there. For this purpose he has used strong solutions of salt, often indeed packing the wound with solid salt for a time, in order to stimulate the free flow of lymph to the area. He has also devoted much time to the continuous irrigation of wounds with hypertonic salt solutions and good results have been reported from this method.

Hopeful progress may also be reported in the field of antiseptic surgery. The ideal antiseptic of course is one which will kill the microbes and not injure the body tissues. The older methods of the application of powerful germicides, destructive of tissues as well as germs, have been largely superseded by the application of more specific substances. This work has centered largely around chlorine compounds. The work of Dr. Dakin and Dr. Carrel, the well-known investigators from the Rockefeller Institute, has resulted in the use of a special technique for the continuous irrigation of wounds with a modified hypochlorous solution. This treatment, according to many surgeons, has led to marvelous results, reducing the bacterial content of wounds to the point where often early closure is possible. This method has become very popular with surgeons, especially at the front, and is, according to many, the best method yet devised in dealing with suppurating wounds.

Dr. Dakin has extended his work by showing that the chlorine from the hypochlorites combines with proteins in such a way as to form substances known as chloramines. These bodies, though possessing a high germicidal value, seem to be quite non-toxic and have no action on albumen. A certain preparation known as chloramin-T has come into very general use, especially in mouth infections, in saturating gauze for antiseptic purposes and as a most efficient throat spray in the treatment of meningococcus carriers.

Another antiseptic that deserves mention is a benzol derivative known as flavine. This was originally prepared in Ehrlich's laboratory some years ago for the treatment of trypanosomiasis. Recently the bactericidal power of this substance has been carefully studied in England by several investigators who find that it is an active and efficient antiseptic without possessing harmful effect on phagocytosis or on tissues

generally. Furthermore, its antiseptic action is actually enhanced in the presence of serum rather than diminished, as is the case with practically all other antiseptics known. It is quite non-irritant and can be used in continuous irrigation after the method of Carrel or in conjunction with the salt pack method of Wright. Brilliant green, another benzol derivative, has been found to possess similar properties and is even more highly germicidal, though it acts less efficiently in serum. Sufficient time has not elapsed nor have these substances been available in sufficient quantities for the thorough and crucial tests necessary to establish them on an absolutely permanent basis as surgical antiseptics. The report of the Medical Research Committee of the British Government on these substances, however, is highly favorable. It is to be noted that these substances are of such a nature that it is possible to combine the methods of the two schools mentioned above, the physiological and the antiseptic, and thus bring the advantages of both into play against microbic invasion of the tissues.

Tetanus.—Lockjaw or tetanus is an anaerobic infection primarily of wounds long feared by the military surgeon. In the early part of the war, especially during the battle of the Marne, when inadequate medical supplies prevented the use of serum, many cases of lockjaw developed. Later, protective inoculation of tetanus antitoxin was administered promptly to every wounded soldier as soon as possible after leaving the firing line and the results have been most gratifying. In the British Army in October of 1914 the ratio of cases of tetanus to wounded men was 32 per 1,000. In November of that year following the introduction of universal immunization of the wounded the ratio fell to 2 per 1,000, at which point and even lower it has continued to the present. Not only has the number of cases been very greatly reduced, but the serum has markedly modified the course of the infections that do occur.

Local tetanus as opposed to generalized disease is recognized as a phenomenon of partial protection. Cases of delayed, late and post-operative tetanus have been carefully studied. Tetanus spores apparently may lie in the tissues for long periods little affected by the antitoxin and later through an operation or trauma may resume their development. Therefore repeated prophylactic inoculations under certain conditions seem essential, especially before surgical procedures. The danger of anaphylaxis is practically negligible.

Curative treatment of the disease by the antitoxin can not be regarded as satisfactory. The intra-spinal injection of the serum is practised, and there is some evidence to indicate its

efficacy, especially when given early. But its curative value does not compare with its protective value.

This data—and the above statements are based on an enormous number of cases—is not new. In general it agrees entirely with what we knew before the war of the value of antitetanic serum. But the war has furnished an opportunity for testing the serum on a scale never before possible and the results have convinced many who previously were skeptical of its value. Before leaving the subject I can not refrain from directing your attention to the enormous number of soldiers saved by this one simple procedure—a procedure, I may say, based upon and made possible by the application of scientific bacteriologic principles.

Gas Gangrene.—Another wound infection caused by an anaerobic bacillus, and quite commonly observed in deep wounds of the muscles, is gas gangrene. The infecting agent is a spore-bearing bacillus, the *Bacillus Welchii*, a common inhabitant of the intestinal canal, clothing and particularly of contaminated soil. Soldiers engaged in trench warfare, and especially those receiving deep lacerating wounds with shrapnel, in which dirt and soiled clothing are carried into the flesh, mostly suffer with this type of infection. The bacillus grows particularly well in muscle tissue, producing an inflammable gas which penetrates tissues where it can easily be detected by the characteristic crepitus.

This infection complicating wounds is extremely serious and nearly always results fatally. The organism appears to produce a highly toxic substance, the real nature of which has not yet been determined with certainty. The prevalence and the seriousness of this infection to the surgeon has stimulated considerable work on the nature of the toxins secreted. Of first importance is the recent work of Bull and Pritchett[2] of the Rockefeller Institute, who believe they have discovered a soluble toxin produced by the bacillus when grown in media containing a small amount of sugar. By injecting the toxin into animals, they claim they have produced an antitoxin which is effective in neutralizing the poison, and animal experiments indicate a definite protective action of the antitoxic serum against the toxin.

Reports of the action of the antitoxin in human cases are not as yet available. Naturally work of this kind needs confirmation before it can be accepted. Repetition of Bull's experiments are going on in various laboratories and we shall

[2] THE SCIENTIFIC MONTHLY, October, 1916, p. 310.

soon know the results. The importance of this work, if confirmed, will compare with that of the discovery of tetanus antitoxin.

Typhus Fever.—The brilliant work of American investigators, especially Ricketts on typhus fever in Mexico a few years before the war, was done at an opportune time. It was then shown clearly that typhus fever is transmitted by the body louse and in all probability only in this way. This fact at once determined the method of attack, and it was soon shown that the disease could be absolutely controlled by the extermination of this parasite. Consequently, when typhus fever early in the war broke out on the eastern front, especially in Servia, medical science was at hand with the proper knowledge of how to control this plague. The excellent work of the American Commission under Dr. Strong in Servia, aided by well-organized British units, is well known to the world. By the elimination of lice, it was possible in a relatively short time to bring the epidemic under complete control.

The etiological agent of this disease has not with certainty been determined. Plotz and his associates in New York believe the agent to be a bacillus which they have isolated from the blood and organs of patients suffering with the disease. They report specific immune reactions with this organism and certain suggestive animal experiments. However, entirely different organisms have been described as etiological agents by other workers. Further work must decide what the true causal organism may be.

This disease has not appeared on the western front and is not likely to. Our American troops are therefore in no danger from this infection. The disease is now known to occur in a mild form in this country, particularly in New York City and in all probability cases have even been observed recently here in Chicago.

Other diseases of a bacterial nature might be briefly referred to, chiefly because of the necessity to cope with them in connection with the military organization of countries. The tubercle bacillus is in many countries, but especially in Belgium and France, decidedly increasing its ravages over peace times. This is due to a number of causes, but chiefly to the poor and inadequate food supply and to exposure. The venereal problem, as usual in wartime, presents itself in formidable proportions. Almost drastic measures have been instituted by the countries in their efforts to cope with these diseases. Germany has enacted stringent laws applicable to soldiers and especially to those who are now discharged and to those discharged at the

end of the war. The radical laws already in effect in Australia with the view to regulate the venereal peril will be watched with interest by all students of hygiene and preventive medicine.

Pneumonia and rheumatic fever in the armies in Europe, strange as it may seem, have not, according to all reports, appreciably increased their incidence over that met with in the civil population. Poliomyelitis has not as yet menaced the military camps.

The above-mentioned diseases discussed in this rather brief way furnish some idea of the more important specific advances that have been going on during the war in the field of bacteriology. In general, it may be said that these advances cover fairly well the entire field of this science so far as it is related to pathogenic bacteria.

Influences of a less specific character are resulting from the war, especially along the lines of general medical research and also in the education of the people in hygienic matters.

The admixture of medical men from various countries brought on by the war, all of whom are necessarily interested in bacteriological problems, has resulted and will result in a most desirable and profitable exchange of ideas, from which we may reasonably expect further valuable contributions to the science.

The education of not only medical men but of the common soldier in military hygiene will in itself be a great stimulus to the science of bacteriology, since military hygiene is so largely based on bacteriologic principles. The instruction now given to the soldiers by lectures and in other ways will make them more intelligent about such matters in general and no doubt will result in an increased interest in this subject by the common people.

The value derived from the physical examination, the military training, the careful supervision exercised in the army over the general health and hygienic environment of the soldier will be of first importance in raising the resistance of the men to the invasion of bacteria of various kinds. The proper control of liquor in itself will accomplish much in reducing the incidence of several bacterial diseases now dependent largely upon the abuse of alcohol.

A most important problem from the standpoint of infections is the proper care of the teeth. Never before has so much attention been given to the hygiene of the mouths of the soldiers and to instruction of the men on this subject. This should eliminate many serious infections about the mouth, jaws and

face, and it will no doubt educate the entire people along a line heretofore sadly neglected. This interest in dental bacteriology in the army is largely due, no doubt, to the progress made in recent years especially in the United States and England in the study of focal infections about the mouth and teeth and the dissemination of such infections to other regions of the body.

I consider it entirely proper here to call attention to the very important rôle that American bacteriology and hygiene has played in this great war. Not only the work done since the beginning of the war but that done before the war has had a most significant application to the great medical problems at hand. The work of Flexner and his associates of Rockefeller Institute on meningitis, the investigations of Reed, Carroll, Lazear and Agramonte, on the control of yellow fever in Cuba, the work of Gorgas in making a health resort of the disease-infested Panama Zone, the work of Carrel, Dakin and a number of other brilliant American surgeons on wound infections and their treatment, the researches of Flexner, Noguchi, Mathers, Rosenow and others on poliomyelitis, the work of Ricketts, Wilder, Anderson, Goldberger and other Americans on the etiology and transmission of typhus and the remarkably prompt and efficient control of the Servian epidemic of typhus by Dr. Strong and associates, the promising studies of Bull and Pritchett on gas gangrene, all these constitute a series of contributions which, from a military point of view, are fundamental in the conduct of a great war. Already we may say American medical science has carried on its side of the military campaign and has set a mark for preparedness which might well excite the admiration of, and indeed furnish a lesson to, the other departments of our military organization.

And finally let me say that while no doubt in a relatively short time this great war among nations will cease, the great war against the countless hordes of disease-producing germs will go on for ages yet to come. This war of man against disease is in every sense a real contest, in which there are pitted against each other mechanisms far more intricate and complicated than have yet been devised by man in the European War. While the contest between man and man may be more spectacular and may involve greater destruction in mass, the assault by the microbes is far more insidious, more elusive, and on the whole far more deadly. Indeed war is in a sense simply an incident which man foolishly permits to enter into that greater struggle with germ life and which often gives the upper hand to the latter. The great armies of men, women and children that are destroyed every year by bacterial diseases make

the destruction of life in Europe seem almost trivial. We speak of this war resulting in the loss and maiming of twenty million lives. Bubonic plague, the black death, five centuries ago in one epidemic in Europe killed twenty-five million persons. One might point to the army of 150,000 in the United States alone carried off each year by the tubercle bacillus, another 150,000 destroyed by the pneumococcus, 25,000 by the typhoid bacillus, several thousand more by smallpox virus and so on. What a pity some of the energy, time and money spent in the great war could not be spent in combating the deadly microbe. A combined attack against several of our great diseases, such as the nations are making against each other, would no doubt result in their extinction. Yellow fever is limited to certain well-defined areas and an allied attack on the several endemic foci would probably exterminate it. Bubonic plague, when not on an epidemic rampage, is localized in three or four well-defined regions of the world. A concerted attack by various nations, using all the modern weapons of microbic warfare, would almost certainly annihilate that triple alliance between the plague bacillus, the rat and the flea, upon which the disease depends for its existence. Asiatic cholera would probably be vulnerable to a well-directed assault. For the existence of several well-known germ diseases, like smallpox and hydrophobia, there is no excuse excepting the stupidity and ignorance of the people. It has been said that we are twenty-five years behind the times so far as the actual application of scientific and laboratory medicine to the control of infections is concerned. In general this is true. For certain diseases like smallpox we are far more than twenty-five years behind the times. We know enough about several of our diseases and have for years known enough to render them extinct. But we do not yet know how to execute this knowledge and to make it bear fruit as it should. This is not primarily a bacteriological or medical problem, but a social one. Indeed it is one of the great problems of democracy.

THE SUN AND THE WEATHER[1]

By DR. C. G. ABBOT

SMITHSONIAN INSTITUTION

"CHANGEABLE as the weather," we say, when the roaring gale follows hard on the heels of a cloudless day. But from another point of view the wonder is that weather changes disastrous to life occur so seldom. Experiments indicate that the higher forms of plants can not grow where temperatures remain continuously below 0° or above 50° C. (32° and 122° F.). These are extremes, and most food plants can only thrive within much narrower ranges. Wheat and maize are grown within the belt whose mean yearly temperature lies between 4° and 20° C., oats and barley —2° to 20° C., rice 20° to 30° C., and potatoes 2° to 16° C.

Despite these limiting conditions, no migrations of men seem to have been forced by climatic changes within historical times, extending over 5,000 years, and there is no evidence to show that the habitats of food plants have altered their latitudes during this interval. Geological evidence, however, indicates that such changes and accompanying forced migrations have occurred in past ages, but probably not of great magnitude within intervals of 5,000 years.

To bring out more strongly this remarkable constancy, in a recent paper Sir F. Stupart says:

> One of the arguments in favor of stability of climate, first used by the Danish botanist and meteorologist Schouw, is as follows: In order that dates shall come to maturity the mean annual temperature must be at least 69° F. (20.6° C.). On the other hand, the vine can not be profitably cultivated when the mean annual temperature exceeds 72° F. (22.2° C.). . . . The palm and vine grew together in Palestine in the days of early biblical history, and they both grow in the same district to-day. . . . That the rainfall of Palestine has not changed in 2,000 years receives confirmation from some measures of rainfall recorded in the Mishnah. . . .

The temperature of the earth depends almost wholly on the balance of two energies. First is the incoming energy of the sun's rays, both visible and invisible, second is the outgoing energy of the earth's rays. These latter are wholly invisible to the eye, and can only be detected by thermometric appliances.

[1] Published by permission of the Secretary of the Smithsonian Institution.

The fundamental nature of earth rays, however, in no way differs from that of light. The only difference resides in their wave-lengths. Light-waves range from 0.0004 to 0.0008 millimeter, earth-ray waves from 0.004 to 0.050 millimeter. The hotter the earth's surface becomes, the more copiously it emits these long-wave rays, so that at a certain temperature of the earth its output of energy to space equals its income, which is almost wholly from the sun. Solar rays lie chiefly between 0.0003 and 0.003 millimeter in wave-length, although extending feebly to very long-wave regions.

Neither sun-rays nor earth-rays pass freely through the atmosphere. Clouds, dust, water-vapor, carbon-dioxide, oxygen, and even the molecules of the air—all hinder the passage of the solar rays. Approximately 40 per cent. are reflected away to space without tending in the least to sustain the terrestrial temperature. Of the remaining 60 per cent. about one fifth, or 12 per cent., is absorbed in the atmospheric water-vapor, so that its heat is distributed through the atmosphere from a level of five miles or more down to sea-level; and about two fifths, or 24 per cent., are absorbed in clouds, principally between levels of one and two miles. Thus it seems that little more than 20 per cent. of the sun-rays intercepted by the earth as a planet are absorbed directly to produce heat on its solid and liquid surface.

An even greater atmospheric obstruction occurs to terrestrial rays. Of the output from the earth's surface, about half is absorbed in clouds, and three fourths of the remainder in water-vapor and carbonic-acid gas of the atmosphere, so that hardly more than 10 per cent. of the radiation of the earth's solid and liquid surface escapes directly to space. By successive radiations from place to place within the atmosphere, the energy does at length reach high levels where it is more free to escape from the earth. Yet the atmosphere plays strongly the part of the blanket upon the couch, or the asbestos covering upon the steam pipe, or still more accurately the glass cover over the hot-bed. In consequence of this blanketing effect of the atmosphere the mean surface temperature of the earth is probably 30° C. (54° F.) warmer than it would be if terrestrial rays passed freely from the earth's surface to space. Not only so, but the change of temperature between night and day is very greatly reduced by the same agency.

Experiments of Lord Rosse, Langley and others showed that in the brief period of a few hours during a lunar eclipse the moon's surface falls from a temperature well above freezing,

even perhaps approaching that of boiling water, to a temperature far below freezing. As the moon is situated similarly to the earth as regards solar distance, but lacks an atmosphere, we readily see from this observation the great value of our atmosphere to equalize temperature. On the earth the maximum range caused by night and day, even in deserts, rarely exceeds 20° C. At most stations the mean daily range is less than 10° C.

Dependent as we are on food crops, which in turn depend on restrictions of temperature range, it seems safe to conclude that human life would be impossible here if it were not for the tempering action of clouds, water-vapor and carbon dioxide, in restraining so strongly the escape of radiation from the earth's surface. These constituents of the atmosphere make hardly 3 per cent. of its weight, but they are the all-important agents for this purpose. Oxygen and nitrogen play little part in restraining terrestrial radiation, though they scatter the incoming shorter wave-length solar rays powerfully, and thus produce the brightness and blue color of the sky.

Many years ago Professor Hann, of Vienna, published an investigation of the variability of mean daily air temperatures from day to day. Ninety stations well distributed over the earth were considered. It may be said, speaking roughly, that the region of United States and Canada from the Great Lakes to the Coast Range, and from the Ohio River to Hudson Bay is twice as variable in climate as any other large area of the inhabited world outside of Asiatic Russia. But as shown in the accompanying table, when we consider the changes on a percentage basis, measuring our departures from the absolute zero where temperature begins, we get an impression of extraordinary stability rather than of changeableness. So great a degree of stability compared with the variableness of other quantities such as length of life, stature, weight and wealth of individuals is indeed almost unexplainable, in view of the variable elements we have been considering, on which temperatures depend. Despite variable screening substances which cut off 80 per cent. of incoming heat and 90 per cent. of outgoing heat, mean daily surface air temperatures in most parts of the world rarely vary 1 per cent. from day to day.

As we have seen, the complete cutting off of solar radiation at night by no means causes the earth's surface temperature to fall to the absolute zero. This is because the darkness does not last long enough to permit the escape of more than a small fraction of the available heat of the earth. We have mentioned the

powerfully hindering atmospheric constituents which cut down the rate of loss of terrestrial heat, and now we may note conditions which govern the quantity of heat available to escape.

AVERAGE NUMBER OF DAYS PER YEAR IN WINTER, SPRING, SUMMER AND AUTUMN WHEN OCCUR VARIATIONS OF MEAN DAILY TEMPERATURE BETWEEN CERTAIN LIMITS EXPRESSED IN DEGREES C. AND ALSO IN PERCENTAGES OF ABSOLUTE TEMPERATURE (WHERE FREEZING IS 273° ABS. C.).

Station	Limits		Number of Days in			
	Degrees C.	Percentage	Winter	Spring	Summer	Autumn
Leavenworth, Kansas.....	0.0 to 1.5	0.0 to 0.5	21	24	29	26
	1.5 to 3.0	0.5 to 1.0	17	20	24	21
	3.0 to 7.5	1.0 to 2.5	29	32	25	30
	7.5 to 15.0	2.5 to 5.0	20	15	4	13
	over 15.0	over 5.0	3	1	0	1
Paris, France.....	0.0 to 1.5	0.0 to 0.5	42	46	45	46
	1.5 to 3.0	0.5 to 1.0	28	28	28	28
	3.0 to 7.5	1.0 to 2.5	19	17	18	16
	over 7.5	over 2.5	1	1	1	1
Sydney, Australia.....	0.0 to 1.5	0.0 to 0.5	50	45	47	58
	1.5 to 3.0	0.5 to 1.0	25	24	24	23
	3.0 to 7.5	1.0 to 2.5	15	19	19	10
	over 7.5	over 2.5	0	3	2	0

Available terrestrial heat varies greatly with the locality. On the water the surface layers, if above 4° C. (39.2° F.) in temperature, contract by cooling, and becoming more dense sink down and are replaced by warmer water from below. Hence a great depth of water, at least 10 meters (33 feet), is available to give up heat. Moreover, the capacity for heat of water is very high, so that a given weight of water gives up about five times as much heat as the same weight of rock cooled through equal temperature difference. Furthermore, the cloudiness and humidity of the atmosphere is generally greater over the oceans than over the land. For all these reasons the daily and yearly changes of temperature are relatively very small over the oceans.

On land, especially desert land, the available heat is much less. No exchange of warm for cooled material being possible, heat can only flow from beneath the surface by conduction. Soil and rock are such very poor conductors that no appreciable change of temperature takes place between night and day on land below a depth of 50 centimeters (20 inches). On account of this, the heat available to escape during the night over a land surface resides almost as much in the atmosphere as in the earth, unless the soil is very wet, so that oceanic conditions are to some extent duplicated. We see, therefore, the explanation of

the great difference between oceanic and continental climates. The former have much the smaller changes of temperature from day to night and from summer to winter. Compare, for instance, the mean hourly and monthly temperatures of Timbuctu and Port au Prince, stations of nearly equal latitude.

MEAN HOURLY DEPARTURES FROM MEAN TEMPERATURES C.

Hours	Midnight	2	4	6	8	10	12
Timbuctu	−4.1°	−5.6°	−6.8°	−7.7°	−2.8°	+3.2°	+6.9°
Port au Prince	−2.6	−3.2	−3.7	−3.8	−0.6	+2.9	+4.7

Hours	2	4	6	8	10	Mean	Range
Timbuctu	+8.5°	+7.4°	+3.4°	−0.1°	−2.4°	29.2°	16.2°
Port au Prince	+4.5	+3.1	+1.1	−0.8	−1.3	25.9	8.5

MONTHLY MEAN TEMPERATURES C.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Range
Timbuctu	21.8°	23.8°	28.1°	32.5°	35.0°	34.2°	32.7°	31.1°	31.8°	31.0°	26.8°	21.4°	13.6°
Port au Prince	24.1	24.6	25.1	25.9	26.0	27.1	27.6	27.3	26.7	26.3	25.6	24.4	3.5

Thus Timbuctu in the Sahara Desert has twice the daily range and four times the yearly range of temperature that Port au Prince on the coast of Haiti does.

Besides the atmospheric blanket and the heat capacity of the surroundings, a time element affects the range of temperature changes attending fluctuations of solar radiation. A rotating disk having a sector of its surface cut away is often used to diminish the apparent intensity of a beam of light. If the disk is rapidly turned, the eye can not detect the changes from light to darkness, and *vice versa*. The effect seen is that of a light of diminished brightness. But if the speed is reduced, fluctuations become more and more noticeable, till at slow speed the full change from light to darkness is apparent. Similarly it should be with changes of the earth's temperature produced by changes of solar radiation. If the solar changes were sufficiently slow, they should produce complete and equal temperature changes at all stations, whether desert or oceanic, provided no secondary changes of cloudiness or humidity, or other variable elements, accompanied.

How large a terrestrial temperature change ought then to follow a slow increase of 1 per cent. in solar radiation?

Evidently the earth's temperature should increase until its

own radiation to space becomes 1 per cent. greater. Bodies which emit radiation by virtue of their temperature are of more or less radiative efficiency, but all natural bodies fall short of the theoretical "perfect radiator." This instrument is closely approached by an enclosure with a minute opening for the escape of its radiation, and with walls of equal temperature. For the "perfect radiator" the emission is proportional to the fourth power of its temperature above absolute zero. It is known that water is very nearly a perfect radiator at ordinary temperatures, and moist soil also. Hence we shall not be far wrong in supposing that the radiation of the earth varies as the fourth power of its absolute temperature. Thus in order to increase its radiation 1 per cent. we should expect an increase of the earth's mean temperature from 287° Abs. C. to 287.7° Abs. C.; for the fourth powers of these numbers differ by 1 per cent. For very slow fluctuations of solar radiation of a few per cent. range we therefore expect 0.7 as many degrees change of terrestrial temperature as the number of per cent. change of solar radiation.

Compare this with the yearly range at Timbuctu. Taking into account the obliquity of the rays and the distance of the sun, the yearly range of solar radiation at north latitude 16° 49′ is 34 per cent. Corresponding to this we expect 24° temperature change. The actual change is 13.6° at Timbuctu. From these figures we conclude that, even for desert climates, changes of solar radiation must be of several years period to produce their maximum temperature effects. It seems probable that solar radiation changes attending the eleven-year cycle of sunspots may be sufficiently slow to produce nearly full temperature effects, not only in deserts but over the world in general.

What changes of solar radiation attend the sunspot cycle? Owing to effects of clouds, haze, humidity and dust in the atmosphere, it is not possible to determine changes in the solar emission of radiation, without using complicated apparatus and methods of observing, and conducting the research at more than ordinarily favorable stations. In short, no observations competent to determine real solar radiation changes were made prior to the year 1905. Since then suitable measurements have been conducted for several months of each year (excepting 1907) by the Smithsonian Astrophysical Observatory, at a station on Mount Wilson, near Pasadena, California. The results obtained give values of the so-called "solar constant of radiation." This is the quantity of energy per square centimeter per

minute received at right angles to the solar beam in free space at the earth's mean solar distance. The following table shows the yearly mean values, usually representing about 100 days each, as obtained at Mount Wilson in the months June to October, inclusive.

SUNSPOTS AND SOLAR RADIATION

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Solar constant...	1.956	1.942	——	1.936	1.918	1.921	1.923	1.940	1.907	1.948	1.949
Spot number....	62.5	53.8	62.0	48.5	43.9	18.6	5.7	3.6	1.4	9.7	46.0

These figures do not indicate a very close dependence between the prevalence of sunspots and the intensity of the sun's emission of radiation, yet they do seem to indicate that there is a tendency to increased radiation when the sunspottedness is rapidly increasing, or at maximum, compared with the period when the sunspottedness is rapidly declining or at minimum. Contrasting from this point of view the mean values for the years 1905–6–8 and 1914–15 with those for 1909–10–11–12–13, we have:

	5 Active Years	5 Inactive Years
Mean solar constant	1.946	1.922
Mean sunspot number	46.1	14.6

If this be regarded as typical, we learn that an increase of 25 sunspot numbers is attended by 1 per cent. increase of solar radiation. The average range of sunspot numbers in the 15 sunspot cycles from the year 1750 to the year 1906 was 90, so that on the basis just stated an average sunspot maximum might be expected to be attended with 3.6 per cent. more emission of solar radiation than the minimum of sunspot activity. This, according to our preceding conclusion, might be expected to be attended with a general *increase* of terrestrial temperature of 2.5° C.

The dependence of sunspots and terrestrial temperature has lately been investigated by the method of correlation (of which we shall say more below) by Dr. Walker, director general of the Indian Meteorological Department. His studies deal with 97 stations in all parts of the world and show that with the exception of northwestern Africa, the west and north coasts of the Eurasian continent, Bermuda, New Zealand and a part of the Indian Ocean, the world in general has *lower* temperature at sunspot maximum than at minimum. Numerical values have been obtained for a great number of stations, and for long periods of years, by several investigators, but notably by

Köppen. He finds that for the interval from 1815 to 1873 the average *decrease* of terrestrial temperature at sunspot maximum was 0.7° C., and for the interval 1873 to 1910, 0.5° C. The difference may well be attributed to the greater average intensity of the sunspot maxima in the former interval.

Here then is a well-established paradox. Increased solar activity, as indicated by sunspots, is attended by decreased terrestrial temperature. It has been suggested, but not demonstrated, that the explanation lies in an increase of cloudiness at sunspot maximum; and that the increase of cloudiness is caused by the penetration of the atmosphere to lower levels by electric ions shot from the sun with greater power at maximum solar activity.

Besides these variations of solar radiation from one year to another, the Smithsonian observations indicate fluctuations which run irregular courses, often in a week or ten days. The true solar existence of these changes has been confirmed in several ways, among others in the years 1911 and 1912 by making the measurements simultaneously in California and Algeria, separated by a third part of the earth's circumference. More recently it has been found that the changes are accompanied by variations of brightness over the sun's disk. Dr. Bauer, too, has shown that fluctuations of the earth's magnetic field accompany them.

As an example of these changes, see the following observations of September in the year 1911.

Date September	3	4	5	6	7	8	9	10	11
Solar constant value	1.888	1.906	1.917	1.960	1.938	1.993	1.948	1.908	1.892

The observed range here is 5½ per cent. in eight days. What effect should this produce on the weather?

Recalling that a change of 100 per cent. in twenty-four hours produces a temperature change of 8.5° C. at Port au Prince, and 16.2° C. at Timbuctu, while 34 per cent. change in 365 days produces 3.5° C. at the former and 13.6° C. at the latter of these two stations, we should expect that for the average station a solar radiation change ranging 5 per cent. in eight days might produce about 0.8° C., or nearly 1.5° F., temperature fluctuation. But as we have seen that for many stations the increase of solar radiation, which seems naturally to accompany the great solar activity of sunspot maximum, is attended by *lower* terrestrial temperatures, we may not be surprised if things turn out less simply than expected in regard to the short interval solar fluctuations.

The subject has lately been investigated by Dr. H. H. Clayton, of Argentina, formerly of Blue Hill, Mass. In such an investigation a natural procedure would be to make two superposed curves, one to show the change of solar radiation day after day, and the other the change of temperature. The trouble with this method is that there are so many influences that operate on the weather, apparently haphazard, that their combined effect often masks the influence under investigation. Accordingly, Dr. Clayton employed the mathematical method of correlation, which has come into general use in biological researches. In this method two functions, like the diameter and circumference of a circle, that are related so intimately that the increase of the one depends only on the increase of the other, are said to have a correlation coefficient $+1$. Two functions, like the heights of two ends of a balance, which are so connected that increase of one depends only on decrease of the other, are said to have a correlation coefficient -1. Between these perfect degrees of positive and negative correlation lie all degrees of dependence, and a coefficient of correlation, zero, indicates that the variables are unrelated. As in other investigations, it is valuable to determine the probable error of each coefficient of correlation, and one considers a correlation standing alone as demonstrated when its coefficient is numerically three or four times its probable error. A group of correlations may, however, so obviously support each other as to lend certainty to the correlation of individuals of the combination, though these individual members would otherwise be doubtful in view of probable error.

Dr. Clayton determined for about fifty stations, well distributed over the globe, correlation coefficients connecting temperatures with solar-constant values determined at Mount Wilson in 1913 and 1914. As he thought it likely that the terrestrial influence of solar changes would be deferred, he computed the correlations not only for identical days, but for the 1st, 2d, 3d, 4th, and 5th days thereafter. Here are examples of the largest correlation coefficients obtained.

Days Following Solar Observations			0	1	2	3	4	5
Station	Latitude	Longitude	Correlation Coefficient					
Pilar	31° 39′ S.	63° 5′ W.	0.32	0.51	0.54	0.48	0.33	0.13
San Diego	32° 43′ N.	117° 10′ W.	0.18	−0.10	−0.29	−0.50	−0.52	−0.44

Probable error about ± 0.07.

From this we see that at Pilar, Argentina, *increase* of temperature followed increase of solar radiation, and the maximum effect occurred after one or two days, while at San Diego, California, *decrease* of temperature followed increase of solar radiation, and the maximum effect occurred after three or four days. The coefficients of correlation at maximum are fully seven times the probable error numerically, so that the connection is well assured. For other stations different values, some positive, others negative, were obtained, ranging down to zero.

When marked on the map the stations of positive and negative correlations were found to arrange themselves very definitely in zones. Speaking roughly, in the zone within the tropics, but broadening over land areas and narrowing over the oceans, the correlation is positive, and so also in the arctic and antarctic zones, and extending down the east coast of North America. In the remainder of the world, comprising the great temperate zones, the correlation is negative.

A similar investigation, but less extensive, was made by Clayton on the relation of atmospheric pressure to solar radiation. Similar zones seemed to be indicated, but where temperatures rose after increases of solar radiation, pressures fell, and *vice versa*.

For several of the stations, Clayton's investigation indicates the actual numerical changes in temperature which follow a change of solar radiation. From the average of all the decided changes of solar radiation, I find from his curves that for 1 per cent. solar change there was 5.2° C. average change in temperature at Pilar, 1.5° C. at Manila, and 6.3° C. negative change at Winnipeg. Other stations would appear to give equally surprisingly large results. Clayton's figures, however, relate to maximum daily temperatures. It may be reasonably supposed that the changes of mean temperature corresponding to 1 per cent. increase of solar radiation would be half as great, or +2.6°, +0.75° and —3.15° C., respectively, at the three stations. We had been led to expect almost surely not more than 0.7°, and probably not more than 0.2° C.

Five thoughts are suggested by this remarkable result. First, that the figures ought to be confirmed by tests extending over other years and other stations. Second, that if confirmed they will indicate that secondary processes are set going in the atmosphere by small changes of solar radiation, which, by altering the atmospheric blanketing effect, magnify in some stations, and reverse in others the natural direct effects of the solar fluctuations. Third, that if such large changes of temperature

are thus caused, investigation may be apt to reveal important effects of solar fluctuations on the winds, cloudiness and precipitation. Fourth, that since the outstanding unexplained departures from mean daily temperatures, as illustrated above for Leavenworth, Paris and Sydney, are seldom of much greater magnitude than the changes which are found by Clayton to be produced by changes in the sun, and as the maximum effects of solar changes follow from one to five days after the cause, depending on the latitude of the station, it may be possible that a very large proportion of weather changes will become predictable for some time in advance, if daily measurements of the solar emission shall be secured. Fifth, that since daily solar-constant measurements of sufficient accuracy can only be had by establishing several new observing stations in the most cloudless regions of the earth, at an initial expense of from $5,000 to $10,000 each, and continued expense of from $5,000 to $10,000 per year each, the occupation of this promising field in forecasting is likely to be deferred until after the war is over.

At present the Smithsonian Institution is alone making the required measurements, at Mount Wilson, California, and Hump Mountain, North Carolina. Weather conditions are not sufficiently favorable at either station to warrant the expectation that on half the days in the year the solar radiation will be properly measured. A projected station in South America has been deferred on account of war conditions, but may soon be occupied. A bequest of half a million dollars to the Smithsonian Institution would enable it to handle adequately this apparently exceedingly important problem.

EVIDENCES OF FULL MATURITY AND EARLY DECLINE

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WE are blessed in America with a between season known as Indian Summer. As the days of autumn grow cooler to colder, somewhere toward the winter comes a genial glow in the air, a seductive restfulness, a luxurious period of weeks in which to bask gratefully in whatsoever surroundings one may be. This contentful interlude is said to be devised for the purpose of encouraging the primitive redman to do his undone chores, to catch up on his neglected provisioning against the pitiless winter. Just such a tranquil span may be reckoned upon when the sun turns and passes the meridian and looks into the face of man as he fronts the setting.

Not all the pageantry of early aging or over-maturity are inflictions to be endured. A peace oftentimes supervenes; a shedding of earlier anxieties; a settling down to an even progress. These are halcyon days in which the heretofore tempest-tossed one may look about, stretch his limbs and give interested attention to what goes on about him.

For most persons the hurly-burly is by then pretty well over; a position of advantage has been reached, the fires of life burn not so brightly, 'tis true, but more evenly. The machinery has become a little worn, weaker in spots, but all bearing surfaces have been abraded to meet each other in a smoother adjustment. There is less friction and far less racking.

When that blessed time has come, one's children are presumably able to look out for themselves; some have left the nest; at least anxieties on their account are subsiding or less urgent. Life's struggles are pretty well settled and progress is accruing.

The body cells are then less irritable; nerve centers are more stable; there is less tension in all voluntary muscles; a general evenness in action has set in. Whatever be our position in the procession of life we know pretty well we must now be content with it, accept such modifications and betterments as we are able to bring about by making the most of what we

have got, what we did with our foundations. Uncertainties are, or should be, nearing their end. From this time on our bodies as well as our careers can only be conserved; not radically changed for better or for worse.

Whatever destiny remains in our hands, to shape it is the part of wisdom to meet that destiny with a serene brow, with thankfulness for what we have enjoyed and are able to retain, to accept the position in life which we have won, to cross off our losses and forget them. It is a time to take account of stock and make up the report upon our trusteeship of that splendid heritage, our body and our mind. Satisfactions will be the greater if we have given reasonable care to the increments of our talents. Some part of a mature philosophy should then have been achieved, due to so much of mental serenity and discharge of duty as we have been able to command. Then we can pass on to other stages of our biologic evolution; of our journey to the grave.

To those who view their past as a mere category of mental achievements the account may not seem large. Compared with those who merely aimed to survive, to "get along," ours is certainly more varied, more vividly absorbing, more worthy of review or exhibition. We should never undervalue our body, however; it is of paramount subservience to or rather correlated with the mind.

Unless we have kept our material parts in good working order to enfold and maintain our soul or spirit, we have failed to "acquire merit" or to sustain the makings of a healthy self-esteem. Few indeed should fail here; no good reason exists for any one to so fail.

The phenomena of overful maturity and early aging deserve to be known, philosophically accepted and serenely assessed. From early maturity to late old age the characteristic retrograde changes are those of wearing out of structures. This wearing out takes place throughout the whole range of actively changing parts, in those which are constantly at work, and is especially seen in those which work incessantly to keep the body going. The constant wear and tear is shown most in the heart, the blood vessels, kidneys; and back of these come the great regulators of life, the ductless glands.

Back of these also lie those fairly stable structures the brain, and nerve cells. It is being demonstrated by the life insurance experts that breaking down (degenerative) diseases are markedly on the increase among all sorts and conditions of men, in all lands and under all circumstances civilized or savage.

One half the causes of premature death are shown to be capable of being prevented as are the infections which now happily are coming under better control. So you see in the final count behavior is paramount; blameworthiness is the reason for most decadence.

Hence it is of the utmost interest for each one of us to learn how we can become aware of the earliest origins, of backward stepping, the parting of the ways. Unfortunately, most phenomena of degenerative diseases are so insidious, give so little warning, that the only wise course is to expect their occurrence, to be vigilantly on our guard against them and live so sanely as to avoid the worst of them.

In order that any one shall protect himself he must learn his own peculiarities, his specific needs, and remodel his life when necessary in accord with the findings. Here instinct helps us much. We are fundamentally aware of what it is right to do and what is necessary to avoid doing. Experts tell us that whereas large gains are being made, notable victories gained, in combating tuberculosis, pneumonia, typhoid fever and other infections, there is a steady increase in the "degenerative diseases" and in the following order of frequency: liver and digestion, apoplexy and nervous diseases, heart, kidneys and urinary diseases. Cancer is not only gaining, but we do not yet clearly know in which directions to proceed to combat it successfully.

Some of the earlier senile phenomena are physical and others mental. Let me mention a few of each. Many can not always be distinguished from evidences of mere culpable neglect of normal precautions or due to laxities in attention.

It may occur that on physical exertion the heart beats noticeably, *i. e.*, one becomes aware of its throb and change in its rhythm or force. It may be over quick or "thumpy"; the breath becomes short for no reason or from slight cause. The digestion becomes more insistent to be indulged or pampered; appetite is more discriminating; taste (usually, not always) more exacting. Hence one's enjoyment of food is greater in one way for qualities and less for the satisfaction of healthy hunger. Appetite is often far too great for safety. Gross feeding occasionally tends to master judgment and must be wisely supervised. Cravings, fictitious longings, habit formed desires for non-essential or hurtful things, must be suppressed.

Since one's whole life tends to become more deliberate, the impulse to stool, to relieve the bowels is now better heeded, time is taken, opportunity welcomed and provided for.

The youthful energetic spring (vulgaliter "pep") no longer joyously activates the muscles. They may be very serviceable, but their energy is no longer exuberant. Weariness is readily recognized and more rests are, or should be, provided for. Fatigue states are not, or should not, be permitted to get too severe; self mastery must not be impaired by the strained attention of subconscious worries. One becomes by this time at least less of a fool in the matter of prodigalities of energizing; hence is ready to take precautions to avoid exhaustion.

Aches and "pains in the bones," really old age changes in the muscles, obtrude themselves. This means that the muscles cells are becoming less vigorous; are being replaced by fibrous tissue and the sensory nerve fibers are pinched by the stiffening structures. To be sure, gouty persons and those who have suffered minor infections in the joints do have some pains in them; they may become slightly swollen and tender on motion and later tender to touch, to pressure or to slight blows. Often finger joints are tender in the morning and this wears off later in the day. However, stiffness with over-sensitiveness to touch as well as motion is a natural evidence of old age changes.

At first these "reminders" are readily overcome by "warming up" at work, by moving freely the arms, fingers, by gentle exercises, walks or work. We may learn of these sensitive joints for the first time to our surprise by some extra pressure or a blow. Many latent tendernesses are due to a condition exceedingly common in middle age, of over-sensitiveness of the junctures of the muscle and fibrous attachments covering them which run into the tendon sheaths. These over-sensitive states are readily overcome as a rule by giving them something healthy to do. They affect the head, being the source of certain forms of headaches; the neck, shown on turning quickly or forcefully; also in the muscles of the eye when put upon a strain.

The urinary organs in older men are peculiarly liable to get out of order: rising at night to pass water is common and may be due to acid or irritating urine, irritable bladder (cystitis, etc.), to old urethral structures or to that scourge of old age, prostatism. This last is a loss of elasticity in the structures of the prostate gland, a mass of tissue surrounding the base of the urethra (outlet to the bladder). This demands prompt and radical attention; it can always be relieved and occasionally cured. If neglected it goes on to a hideous distress.

In women, especially in those who have had children and in whom the pressure of the pregnant uterus has overdistended the bladder, or in whom injuries to it have occurred in par-

turition, urination may be greatly disturbed and control lost. Leaking of urine, only too frequent, needs early and thoroughgoing attention. The act of urination is easier in later life in both males and females, which may also be a source of harm, causing the impulse to void to be disregarded. Urine accumulates, the bladder becomes distended, therefore dilated.

On the other hand, difficulties in voiding urine or the complete emptying of the bladder tends to apathy and neglect.

As the energies subside, unless there be some stimulus, some object or ambition to keep one interested in activities, the tendency is to omit care of the person, of suitable hygiene, and to fall into indolent habits; indeed, to become a nuisance to others. The one imperative need for the aging is action, wholesome doings, use of parts, changing of scene and circumstances. "Vanity is the mother of all the graces" and pride is a boon to old folks.

One notable alteration occurs in over maturity which, though merely esthetic, is significant. Emanations from the skin become offensive; fatty acids are formed producing different, repugnant or fetid odors. A dank mustiness replaces the normal pungency. To overcome this skin friction is more effective than mere bathing. Many devices are offered to neutralize these malodorous effluvia, but the best one is bodily hygiene and activities. The sweat often markedly increases or is suppressed; if insufficient the thyroid action is depressed. Reasonable activities are always needed to keep the skin action normal.

As old age advances so do heat making powers subside. Help is then needed to maintain combustion. The temperature sense becomes deranged. Chilliness is readily felt, artificial heat is craved; greater weight of clothing, warmer underwear is needed. Insensitiveness leads to evil effects of undue exposure, to chilblains, also to loss of local vitality, occasionally to gangrene. In others heat loss is impaired, the skin then acting badly, hence the surface is hot and dry, unrelieved by perspiration.

Changes in the ligaments and bones occur in the middle aged as well as during decline, inducing deformities in joints, particularly in the fingers and toes. Earlier defects become accentuated, such as bunions, fallen arches, flat feet, hammer toes. In old men there is usually a slouch, a drooping of the shoulders, a shrunken chest, bent knees. During maturity this disfiguring state too often is seen, mainly due to carelessness. In the old it then is also a weakening of the erector muscles of

the back. In women this is more rare, they being supported by vanity, a desire to maintain a good appearance.

Habit attitudes are often the chief factors in acquired deformities, notably desk workers, drivers and others who must sit for long periods on uncomfortable seats. All these deformities are mainly due to carelessness and can be prevented or limited by reasonable care; intelligent attention; a wish to keep a good form. This subject of posture is of real economic as well as of esthetic importance, as the tissues lose their pristine tone.

The disks of cartilage between the sections of the backbone in old people atrophy, but this comes late and need do no more than cause a shortening, not necessarily a bending. One of the most graphic and conspicuous features of aging, often seen in late maturity, is a slouching, slinking walk, uncertain feeble steps, a tottering-shuffling gait. This is directly due to loss of elasticity in the muscles (or rather aponeuroses and fibrous attachments) of the legs. Of course a relative degree of weakness contributes, but both can be alleviated; the one by passive stretching of the limbs, the other by attention to nutrition.

The teeth tend to fall out by reason of the shrinking of their sockets. Of course caries and pyorrhœa and other diseases contribute to dental losses. There are those who claim that tooth loss is a wise provision of nature to warn against the continuous use of meat and solid foods. Be this as it may, the best advice is to get rid of all suspicious teeth, especially any which have abscesses at their base and to "buy a store set"; chew your food thoroughly and add to your strength and length of days.

Nothing so marks the turning point of vigor, of efficiency, in short the advent of senility (abnormal old age), as loss in the organs of special sense. Time was when the lenses of the eye had begun to flatten and near vision was impaired, a man or woman was practically relegated to the scrap heap. Now we know that by the single device of wearing correcting glasses the years of usefulness, not to speak of progressive intelligence and happiness, become indefinitely prolonged.

One point should be emphasized here: A large proportion of degenerative conditions of the eye, disablements of diverse kinds and degrees, can readily be prevented by having the eyes examined early and in wearing correcting glasses and other devices to bring vision up to normal by mechanical and other adventitious aids. This is particularly significant in the case of cataract. Let brain workers, especially literary men, take notice.

Even to-day one meets dear simple old bodies who confidently repeat the errors of a half century ago (when the light of ophthalmology had scarcely dawned) that they personally *avoid* the wearing of glasses as long as possible, seeming to enjoy the condition of having performed a meritorious duty. Worse than this archaic folly is the arrogant conceit of those who refuse to have obvious and glaring defects in their own eyes corrected, or (most unforgivable) those of their children.

No one agency so fully compensates losses of capacity and capability due to aging as the use of properly fitting glasses to correct errors of refraction. Hearing is only second in importance in this connection to vision. Conservation of hearing is of paramount importance. Knowledge of the causes and cure of deafness has grown pari-passu with that of blindness.

Of the two sense organs, touch and smell, both of which become impaired as aging progresses, we need not dwell upon at this time. Taste, however, is of deep significance as years go by. It bears directly on the subject of nutrition, choice of foods and dietetic habits. A smaller amount of food is required after full maturity. The structures in middle age are all fully developed, or ought to be; hence structure building foods should be taken in smaller amounts. Taste for them naturally subsides, an instance of adaptation to changed conditions of structure and function. The hydrochloric acid and stomach juices are less, hence a craving for pungent highly stimulating substances like pepper and salt usually remains. Acids are craved, and fruit acids are of much value. Alkaline and insipid foods are disliked.

Decomposition in the intestines is increased though the products give less discomforts. The total amount of urea and uric acid eliminated is far less in old age; only about one half the CO_2 is exhaled as in early maturity. Fats are not needed, they are the chief fuel, hence the bile is diminished.

Disease processes and their effects peculiar to the descending epochs must be reckoned with in addition to the normal and usually recurring changes of late maturity and aging. In every one slight injuries have occurred in earlier years, some of which leave strains, scars, alterations in structures, which may give no evidence of their existence till weaknesses and deteriorations in structures set in, as senility approaches.

Some of these injuries (traumata) induce habits of wrong use or disuse which limit or vitiate normal action or function. Effects may be shown in peculiarities of motion, of speech (articulation), of attitude, of energy or of indolence.

Attitude errors, posture peculiarities or anomalies, commonly result from slight injuries. Also errors of gait, limps, of placing the feet arise, many of which can be corrected or eliminated. Acquired faults from ill fitting clothes, corsets, shoes, collars, belts, braces, occur in many persons unless vigilantly watchful.

Habits of using canes for support, even of crutches, may be the result of slight injuries, long recovered from. Fear, apprehension, cause these to remain, and the need for them is psychic and fictitious. There may be some local rigidity, some limitation of normal motion, quite curable. These conditions form a fertile psychopathic ground for quacks, charlatans.

Aching tiredness is common in those who remain much in wrong attitudes or in disease. The cure is simple and imperative, abundant varied, wholesome action. The older these errors are the more difficult to eradicate; the more difficult to reeducate to normal uses.

A BOTANICAL TRIP TO THE HAWAIIAN ISLANDS. II.

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LANAI

A few days were spent on Lanai as a guest of Mr. George Munro, manager of the Lanai Ranch. Mr. Munro, an amateur botanist, familiar with the flora of the island, accompanied us on our trips and was of great service in bringing to our attention the rarer plants. The eastern part of the island runs up into a forested ridge, the highest point of which is about 3,500 feet (Fig. 31), the eastern slope steep and broken with precipitous gorges, the western slope gradually descending to a dry grassy plain. A species of prickly-pear cactus (*Opuntia megacantha* fide Dr. J. N. Rose) has become established here over wide areas and also on the dry regions of other islands (Fig. 32). *Paspalum dilatatum* is proving especially valuable as a pasture grass on the mountain slopes.

MAUI

Maui, the second largest island of the group, is divided into two mountainous masses with a low isthmus between, the two parts being known as East Maui and West Maui. Our investigations on West Maui were conducted from Lahaina on the west coast (Fig. 33). Through the courtesy of Mr. L. Weinsheimer, manager of the Lahaina Sugar Plantation, we were able to visit the highest peak, Puu Kukui, the summit of which is 5,788 feet. Mr. Munro accompanied us on this trip. We ascended the mountain as far as was possible with horses. The trail became so bad that the pack horses were mired and could go no further. The supplies were carried about half a mile further up, where camp was made, the horses being tied in the mire until the third day, when we returned. The tents were pitched in a small opening in the woods, but there had been so much rain that the ground was very soft and soon became mire all around the camp. The trunks of tree ferns were cut and placed in the paths to walk on. The tents were pitched in the rain and no fire was possible until the evening, when enough

FIG. 31. LOBELIA IN HUMID FOREST NEAR SUMMIT OF MOUNTAINS, LANAI. A common climbing fern (*Gleichenia*) in foreground.

was made to prepare tea. The following day we made the ascent to the summit, returning to camp for the night. It rained nearly all the time and the trail was very wet and muddy. The most interesting feature of the vegetation is an open bog near the summit, a type which we found later on Molokai and Kauai. The bog is devoid of trees and large shrubs, though there are some small inconspicuous shrubs lying close to the surface (Fig. 34). Many plants form tussocks raised above the general surface. One of the most conspicuous of these is a sedge (*Oreobolus furcatus*). Three species of

FIG. 32. A CACTUS FOREST ON LANAI. The cattle have grazed off the lower branches.

Panicum are tussock-forming, *P. monticola*, *P. imbricatum* and *P. isachnoides*. These species are peculiar to the bogs. The most conspicuous plants were a species of *Lobelia* (*L. Gaudichaudii*) four to six feet high, with a pyramidal panicle two feet long of large showy cream-colored flowers, three to four inches long, and a species of *Wilkesia* (*W. Grayana*) similar in size of plant and inflorescence, with heads nearly an inch in diameter.

On East Maui is the famous Haleakala Crater said to be the largest crater in the world. Through the courtesy of Mr. Louis von Tempsky and Mr. S. A. Baldwin, of the Haleakala Ranch, we were able to spend four days in this crater. We remained one day at Idlewild near Olinda, on the north slope of Haleakala. Thanks to a pipe line, we were able to penetrate

FIG. 33. A MOUNTAIN GORGE NEAR LAHAINA, showing the steepness of the valleys.

FIG. 34. A SMALL OPEN BOG NEAR KAHOLUAMANO, KAUAI. Forest in background.

the humid forest for four or five miles. One of the plants found on the slopes of the deep wet ravines of the islands is *Gunnera petaloidea*, with huge circular leaves three or four feet in diameter (Fig. 37).

We descended into the crater at White Hill, the rim here being about 10,000 feet altitude (Fig. 35). There is here a

FIG. 35. HALEAKALA CRATER FROM WHITE HILL, the pass at the west margin (10,000 ft.). Clouds rolling in.

FIG. 36. SILVER-SWORD. A sterile plant brought from a cinder cone, supported in lava for photographing.

very fine view of the great crater, lying to the east, nineteen square miles in area, with many cinder cones within. One of the most interesting plants found here is the silver-sword (*Argyroxiphium sandwicense*), a member of the family Compositæ (Fig. 36). The narrow sword-like leaves, borne in dense hemispheric clusters, are covered with a silvery appressed tomentum that glistens in the sun. From the center of the cluster arises the flower-stalk bearing a large number of heads of flowers. The plants grow on the slopes of the cinder cones far above other vegetation and look at a distance like a flock of sheep. The silver-sword in a somewhat modified form grows on Mauna Kea and Mauna Loa but not in abundance. While climbing the western wall of the crater I had the misfortune to fall about fifty feet, escaping death by a very narrow margin.

MOLOKAI

This island lies with its greatest length east and west. The eastern half is mountainous (Fig. 38), the mountains ascending steeply but evenly on the south side, but dropping off very precipitously on the north side. The western half, more level and much drier, is occupied by the Molokai Ranch. The leper

settlement is on a peninsula on the north side of the island below the mountains. On the summit of the ridge is an open bog similar to the one on Puu Kukui.

KAUAI

Kauai, the Garden Island, the most northerly and the oldest geologically, is nearly circular in outline and rises somewhat uniformly to the central highest point, Waialeale, 5,170 feet altitude. The erosion on this island has been extensive, resulting in deep gorges and canyons. We visited Olokele Gulch (Figs. 39, 40), a very picturesque canyon a few miles from Waimea, but the main trip on the island was the ascent of Waialeale. This is a rather inaccessible peak and has been visited by few botanists, the first being the Austrian, Dr. Wawra. Professor Rock had ascended the mountain a few years previously and we were fortunate in having him with us

FIG. 37. A LEAF OF *Gunnera petaloidea*, brought down to Idlewild from the humid forest along the Olinda pipe line, Maui, near Haleakala.

FIG. 38. SOUTHERN MOLOKAI, NEAR MR. CONRADT'S PLACE, PUKOO. Looking up one of the steep valleys toward the central range.

on our trip. An account of the trip will be given somewhat in detail as it illustrates the difficulties of botanizing in wet regions.

We made our headquarters at Kaholuamano, a mountain house belonging to Mr. Francis Gay. The party consisted of Professor Rock, Albert and myself, and the Hawaiian guide Kualu, who has made the trip several times. We started from the mountain house in the forenoon, going with horses as far as the trail permitted, a distance of perhaps three miles. A Japanese helper took back the horses, but was to return to the same place on the third day to meet us. We then set out on foot, carrying our supplies on our back. We had food for three days, a meagre set of cooking utensils, blankets, extra change of clothing throughout, and a small camera.

The upper part of the mountain is very wet. A rain gauge is maintained on the summit which is read once a month. As much as 600 inches per annum have been recorded. Consequently the trail is very muddy and one often sinks to the knees, even when picking one's way. As the trail is traversed rarely except the monthly trips to the rain gauge it is not kept well cut out. About a mile of the trail is in the bed of a mountain stream. We were all wet through from head to foot as it was raining most of the time. The first night was spent in a cave (Keaku Cave) on the side of a very steep hill or cliff. The cave is an ancient one that was occupied by the natives on trips to get bird feathers for use in making royal robes. It is high up on the side of the cliff, perfectly dry, but without an approach save a steep path at one side and drops off suddenly at the front. The depth is only sufficient to give shelter to a few people lying down. In the cave we found a supply of white paper "inner sheets" left there by Professor Rock five years before. Fire wood is cut by each party occupying the cave and stored, so as to be dry for the use of the next party.

On the second day we started for the summit. A large open bog occupying several square miles stretches from the summit of Waialeale northwest along the plateau back of the main ridge, called the Wainiha Pali. This ridge is very steep on the northeast side, but gently sloping or almost level on the southwest side. The bog is about ten miles long and one or two miles wide. The plants are about the same species as are found in similar bogs on Molokai and West Maui. The bog extends to the summit, over which the cold wind blows with great violence. Here and there are pools and ponds. The cold wind blowing on our wet clothing chilled us thoroughly and we were glad to commence our return.

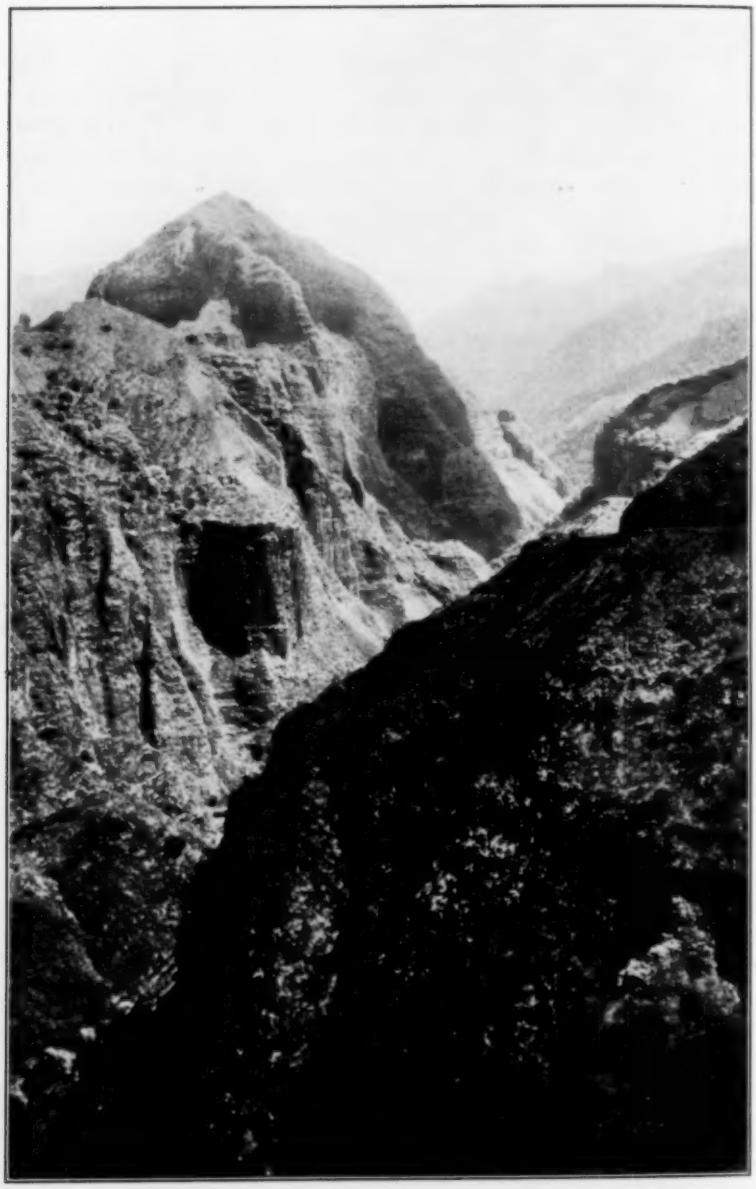

FIG. 39. OLOKELE GULCH, KAUAI, showing the effect of erosion.

FIG. 40. OLOKELE GULCH, KAUAI. The trees with light-colored foliage are Kukui (*Aleurites moluccana*).

The second night was spent at the cave and on the third day we reached Kaholuamano. The return was even more arduous than the outgoing trip. The load was heavier because of collections, which were not offset by the consumed provisions, and furthermore the rains had been heavy and continuous, so that the streams were higher and the trail more water-soaked.

A few days were spent at the mountain house, collecting in the vicinity. A very interesting species of *Poa* obtained on one of the ridges has been described by Professor Hackel as *Poa siphonoglossa*. It grows in large tufts on the steep slopes just below the top of the ridge. The numerous culms are several feet long, leafless, green, and have the appearance of a

FIG. 41. REPRESENTATIVES OF THE LOBELIA FAMILY; peculiar palm-like forms.

bullrush except they are lax and hang down the bank. The flowering culms are shorter and bear leaves to the summit. The spikelets and the flower culms look like those of *Poa*, but the rush-like sterile culms are different from any known species of that genus.

One of the interesting families of the Hawaiian flora is the Lobeliaceæ, represented by about 100 species belonging to 6 genera. The numerous arborescent species are very peculiar and characteristic. Many of them form slender trunks like small palms, crowned with a large cluster of long narrow

leaves (Figs. 41 and 42). The trunks of some species are as much as 30 or 40 feet high and the large bright-colored flowers are sometimes remarkably beautiful.

The ferns of the Hawaiian Islands are numerous in species and individuals. They are the dominant feature of all the wet forests. Three species of tree ferns (Fig. 43) of the genus *Cibotium* are found and in some places form extensive forests.

FIG. 42. AN ARBORESCENT SPECIES OF THE LOBELIA FAMILY (*Cyanea* sp.), a group highly developed in the Hawaiian Islands. Forests of central Kauai.

FIG. 43. TREE FERNS (*Cibotium Menziesii*) IN THE KOHALA MOUNTAINS. Those in the foreground are in a pasture and the surrounding vegetation has been kept down. In the background the ferns are mixed with other vegetation in a dense mass.

These produce at the base of the stipe a great ball of brownish-yellow wool called pulu by the natives and used by them for stuffing pillows and mattresses. One species (*C. Menziesii*) is shown in Fig. 43. Contrasted with the tree ferns are numerous small epiphytic forms, some species with fronds only an inch or two long. The ferns and fern allies number about 170 species.

THE INFLUENCE OF ANTHROPOLOGY UPON HISTORY

By WILSON D. WALLIS

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THE definition of history as a record of past events suggests the advertisement of a certain firm which promises to teach one how to train the memory. This man, it says of the discoverer of the system, can give the size of every city in the United States having a population of over 5,000, and can give the dates of two thousand historical happenings. This Cinquevallian feat of memory may afford the possessor, and others who enjoy such harmless pastimes, considerable amusement; but certainly no one who has burdened his poor mind in this way can hope to be of any use to society. He has learned figures, but not history; he might make a mathematician or a guide to railroad schedules—he certainly could never become a historian.

For the sake of history itself it is entirely regrettable that the insistence on a series of dates as the groundwork of history was not carried at once to its logical conclusion. It is not enough, such logical insistence would tell us, to know that the Hegira occurred in the first half of the seventh century; we must know that it was in the year 622. Nor is that enough. We ought to know that it occurred at 6:15 P.M., on August 3, 622. No less exactitude should be demanded of those who find the beginning and end of history in dates. They may then take their place with those earlier Biblical scholars who declared the date of the Creation to be the year 4004 B.C., October 28, at four o'clock in the afternoon.

Dates are comparatively unimportant for two reasons: In the first place, simply as so many isolated dates they add no more to our knowledge of an event than if we described the temperature rather than the time of year when they occurred. After all, why should the historian have his eye always on the calendar rather than on the thermometer?

Furthermore, dates are comparatively unimportant because they are only relatively true. Indeed, dates are more false than true; they are more often misleading than enlightening. Take, for example, the French Revolution. The older histories tell us

that it began in 1789. No modern historian would be so clear-cut. The French Revolution began—who would say when it began? It certainly had its roots in an intellectual revolution, in a spirit of change, in a new attitude of mind, in new philosophies of life and of society, and in new foundations of human and political rights. It matters not what important historical event you select, you can not give it an exact date unless you do this arbitrarily and in defiance of its prior existence and development. The reason is plain enough: they are not events, in the sense that they are mere happenings. Rather are they but the climax of a development, the crest of a wave which is important, not because it is a crest, but because there is a wave back of it. The amplitude, the sweep, and the direction of that wave rather than the crest itself constitute the importance of the historical event. Might we not, indeed, say that historical events are important just in so far as they are not mere happenings, isolated episodes, but represent one phase of some deep-lying and long-continuing development? Such, at least, I take to be the meaning of history, if we are to give up dallying, like mental sleight-of-hand performers, with so many happenings and dates, and instead take our subject seriously and hope to make it profitable.

What, then, does anthropology have to do with this conception of history? I reply that it both has had, and still does have, a great deal to do with it. From anthropology more than from any other quarter, not excepting history itself, has come the conception of history as a continuous development. Whereas the older history treated human progress as going forward by so many leaps and bounds or as a succession of unrelated happenings, anthropology has developed and vigorously applied to almost all phases of human life the conception of a gradual development, of a progress that differs in rapidity and may have many a set-back, but is nevertheless essentially continuous throughout. If one may be permitted the comparison, from the first, history has thought of man as advancing after the manner of the frog, while anthropology, from the first, has insisted that he has one foot ahead only when and because the other is behind. Anthropology has largely accomplished its task through observing that human nature is much the same the world over, and that what it is to-day is largely because of what it was yesterday. We are gradually coming to see that history is one continuous, unbroken thread and not a vast collection of fragments.

From anthropology history has gained more than this idea

of human life as a continuous development. It has taken over from anthropology a method of interpretation which is a corollary of the theory of continuous development. This corollary is that civilization, in all ages and in all stages of development, has a remarkable conservatism. Social life, like a physical body, tends to remain in its original condition. Let it start moving in one direction and it is easier to keep on than to stop. This application to history of a simple and long-recognized law of physics has called for many a reversal of the current interpretation of events. It gives a new insight into causes. We used to think it obvious enough that a people adopt or continue a certain institution because they like it; we now see that there is as much truth in the converse—they like it because they adopted it and continued it. It is just as true that we like democratic institutions because we have them as that we have them because we like them. I do not believe that any historian professes to have discovered this principle. It was the insight of an anthropologist, a friend and contemporary of Darwin, E. B. Tylor, who first made this clear in his "Primitive Culture," and "Early History of Mankind." He showed that many beliefs, customs and institutions can be given no sufficient explanation without the historical setting, and this exhibits them as survivals of a previous civilization of which they are the outstanding remnants. The historian is coming to make more and more use of this instrument of interpretation, and with increasingly valuable results.

So much for the contribution of anthropology to history by way of methods of interpretation. What has it contributed in actual material, in the data that must be used?

Here, too, the contribution of anthropology has not been negligible. It has enlarged the horizon of history at every point, but most of all at its beginning. What the anthropologist calls pre-history is as much history as ancient history or medieval history is history. In all cases it is the reconstruction of the past from existing documents. It matters not whether these documents be written or unwritten. In fact it is often much easier to interpret the unwritten than to interpret the written. Prehistoric anthropology has given us a hitherto unsuspected insight into this nebulous past. The vistas have not only lengthened into tens of thousands and even hundreds of thousands of years, they have also been given a content; they are no longer barren, but tell a story. That story discloses to us the long processes by which crude men of the stone age have fashioned their crude weapons, gradually improving upon the

experience of the past. This improvement can be traced in some detail as the implements become more highly specialized and give rise to new types which, in turn, are improved and throw off further new types. Even the artistic ability of the man of tens of thousands of years ago has been preserved for us. We know also the story of the domestication of the animals, which first served him as food, and of the care of those valued plants which later he assiduously cultivated. But the details of this story can not be given in a few words.

In another and distinct manner anthropology has been a valuable maid-servant to history, namely, in the understanding it has given of those peoples with whom civilization has had most to do and which have had most to do with it. So far as American history has been influenced by the Indian tribes, this portion of it is as much anthropology as history. When one reads the average historian's account of these tribes there is reason to regret that no larger element of anthropology has gotten into it, for most of these accounts are three fourths misconception. Moreover, every European nation has been largely affected by the ideas or customs of primitive peoples, within or without its bounds, and these influences are usually best estimated by the anthropologist.

It remains to ask to what extent writers of history have, at the same time, been anthropologists. In this matter, as in most others, the Greeks deserve first mention. Herodotus, the Father of History, has equal claim to the title of Father of Anthropology. I know that he has also been given the third title, the Father of Lies; but a better understanding upon our part of the conditions which he describes has tended in the main to confirm rather than to discredit him. He was the first one to grasp the fact that to know merely the history of one's own people is not to know that history. Here, as elsewhere, comparison is the mother of clearness and the true dimensions of a subject can be seen only when that subject is viewed through some perspective.

Herodotus realized that if he wished to discover the causes of the Greek and Persian wars he must go to the Persians as well as to the Greeks. He knew that those causes could not be explained by a few outstanding facts, for this would be to mistake the occasion for the cause. He, therefore, studied Persian customs and Persian dress, Persian superstitions, religions, politics, and all that went to make up the character of the individual and determine the nature of the civilization. He may have made many mistakes, but much can be forgiven the pioneer.

Herodotus's faith in the value of the comparative anthropological method was not solely academic. He himself visited the Mediterranean peoples and attempted to fathom their civilization. He gives us an intimate account of many Egyptian beliefs and customs. While this account revealed to the Greeks a new civilization, it must at the same time have shown them their own civilization in an entirely new light. They had been looking out upon the larger world through the medium of their own culture. Herodotus enabled them to stand without their own world and look upon it from a new standpoint. He thus objectified for them the intimate conditions of which they were so thoroughly unaware, just because these conditions were the glasses through which they had been looking. Their state of surprise must have been comparable to that of M. Jordain when he suddenly awoke to the fact, hitherto unsuspected by him, that he had been talking prose all his life.

Herodotus's comprehensive grasp of anthropological method is surprising. In his account of the Scythians, for example, he gives us nearly all the categories that we find utilized by a trained anthropologist of the present day. He has not worked out the details with as much care or insight as our contemporary investigators; and it would be nothing short of a miracle if he had.

After Herodotus the most noteworthy anthropological historians were Strabo and Diodorus Siculus, from whose studies of the tribes known to them we glean our most valuable information of the ruder Mediterranean peoples. Each of these writers is to-day an invaluable source of information for the anthropologist as well as for the historian.

To the Romans, also, we are under especial obligation. The Commentaries of Cæsar, the Agricola and Germania of Tacitus, are good anthropological works as well as good history. The great historian of the German peoples, the late Lamprecht, is insistent that German history, to the present, is but the unfolding of germs of development lying latent in these crude Teutonic tribes of which these writers tell us at once so much and so little. Indeed, it would scarcely be going too far to say that without the anthropologist Tacitus we should not have had the historian Lamprecht, just as we would not have had modern Germany if there had been no Germanic tribes. The study of these tribes is essentially anthropology while the study of German States is essentially history. But who will say where the one begins and the other ends?

In Plutarch we have a good example of the comparative

historian who also attempts the anthropology of his own people. If his *Lives* constitute history as well as biography, his *Questiones* is certainly anthropology. As Lucretius was the first to recognize and picture the evolution of civilization, so Plutarch was the first to recognize the importance of survivals and the permeating force of conservatism. His analysis of these survivals gave an insight into existing customs which hitherto had not been suspected.

Unless one class as historians the students of comparative law, such as Montesquieu, Locke, Sir Henry Maine, there was no union of the anthropological and historical interest until the last century. The Spanish theologians had, at an early date, begun their fantastical proofs that the American Indians represented the lost tribes of Israel, and certain English writers, as notably, Adair, continued the ill-founded fallacy; but not until Prescott, Bancroft, Maximilian von Wied, Catlin, Schoolcraft, and a host of American writers, do we find anthropology and history keeping step.

The spirit of Herodotus is, however, still abroad and is settling on the heads of many of our contemporaries; in Germany on the historians of *Kulturgeschichte* and in America on historians of every school. McMasters finds it necessary for American history, Robinson for any history, Breasted and Hutton Webster for their ancient history. A new era, an anthropological-historical era, is dawning.

To sum up: anthropology has brought into vogue new methods of studying human civilization and these have been taken over by history. Its concept of a continuous development has made of history something more than a mere recital of events and has given a clue to the continuity of institutions and customs. It has extended the old boundaries of historical research and has introduced a new perspective into human culture. It has introduced an objective and comparative method which, now that its value has been grasped, will never be surrendered.

THE EDUCATIONAL THEORY OF SOCIAL PROGRESS

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CIVILIZATION is essentially an acquired trait. Its basis is the accumulation of a mass of habits which are transmitted from generation to generation through custom and tradition. Each generation has therefore to acquire this ever-increasing mass of habits which make up human culture. So far as we know, biological selection can do nothing more than equip individuals with hereditary powers and capacities to acquire this mass of habits from their social environment. There is no evidence which would warrant us in believing that the children born in the most advanced civilization are inherently more civilized than the children born under the most primitive conditions. They are simply born in a more favorable environment in which social machinery aids them to take up the habits, knowledge, standards and values of the civilization which surrounds them. It follows from these simple statements that the methods of continuing and developing human social life in its cultural phases must be essentially of an educational nature.

The educational nature of the social life process would seem to demand, accordingly, more serious consideration than has usually been accorded to it by most sociologists. Whole volumes have been written on social progress with scarcely a mention of educative processes. On the other hand, educators surely need to realize, even more than they have done, that in dealing with education they are treating of a most essential and vital phase of the social life process, and that education has always been and must remain the main method of social progress. Gratifying advances have been made in this direction within the last few years, both by educators and sociologists; but something still remains to be done to bring together and to coordinate the results in both fields. It is the purpose of this paper to endeavor to make a contribution in this direction by considering education as a means of social development and progress.

It should be stated at the outset in discussing the educational theory of social progress that education is to be con-

sidered as a method, not as a cause, of progress. The causes of progress undoubtedly lie in the stimuli in the environment and in the nature of the human individual. To acknowledge this, however, is in no way to detract from the importance of education in the theory of social progress. For in all practical sciences the question of method becomes of as great importance as the question of cause. It is the expansive power of steam which causes the engine to run; but the efficiency of the engine will depend very largely upon the method by which this natural force is controlled and applied in any particular case. So it matters not whether we decide that the causes of progress lie in the stimuli in the environment, or in the energies wrapped up within the individual, or in both; the question of how these causes can be made to work most effectively and harmoniously still remains to be settled.

Our thesis is that the active factors in progress can be most advantageously, economically and effectively controlled in human society by the educative process. We mean by the educative process the whole process of controlling the formation of habit and character, of ways of thinking and ways of acting, in the individual. Formal education, to be sure, may be only a very small part of this process; but, as social evolution has advanced, there has been more and more a tendency to make this process one of conscious and intelligent control. It is of course the process as conscious and intelligent which we take as our norm usually when we discuss education as a means of social progress. Nevertheless, it should not be forgotten that the more intelligent and highly conscious phases of the process have sprung out of less intelligent and less conscious phases of the same process in the course of social evolution. Education in this respect only illustrates what is true of all phases of our social life; namely, that there is an increasing tendency to bring them into consciousness and under the control of intelligence as social evolution advances. It should be needless to remark, furthermore, that the school is not the only institution in which the educative process has been brought under a high degree of conscious control. The home, the church, the press, the public address, illustrate in hardly less degree conscious efforts at controlling the formation of habit and character, ways of thinking and of acting, in the individual. In a more narrow and specialized way, the same thing is true of other social institutions, such as the shop, the factory and the marketplace. Wherever we have the use of artificial means of controlling the formation of habit and character in individuals,

we have an educative process. The school, perhaps, has become, in the latest phases of social evolution, the central institution concerned with the educative process; and in so far as it can succeed in coordinating all of the other educational agencies in human society, to that extent what we say of education as a means of social progress will be true of the school also.

The idea of human progress being essentially a process of education is a very old one. We find it first, perhaps, clearly enunciated in Augustine's "City of God." But, it did not become a favorite way of looking at social development until the eighteenth century, when we find such writers as Turgot, Lessing and Herder frequently setting it forth. These writers are usually represented to have developed merely an interesting analogy. They are represented merely as saying that history is the development of the species brought about through the course of instruction which nature affords! This, however, is an unfair representation of the thought of these writers. Rather, it is more clearly expressed in the aphorism of Paley, "All the generations of men are like one man, ever living and ever learning." While the continuity between the generations is here represented to be much closer than it really is, still the meaning is clear enough. History is represented as a process of self-development, the self-development of humanity instead of the individual. It is a learning process, a process in which experience is accumulated and consolidated in the social group, much as it is in the individual mind. In Turgot's famous essay on "The Successive Advances of the Human Mind" progress is thus shown to be the organic principle of human history. Each generation accumulates experience and passes it on to the next in the form of knowledge, standards and values. Thus, as experience is accumulated, and as the race learns through experience, progress is bound to result. Just as the individual grows in wisdom and in character through the experiences of life, so the race is bound to develop. Turgot recognized, however, that there were times of moral and intellectual decadence, but these he contended were not in contradiction with his general principle. They were times when the wisdom of the past was neglected, or when some new situation rendered it inadequate, and mistaken choices were made which resulted in temporary retrogression. Thus, progress might be interrupted, but society was bound to learn from the very mistakes which it made, and in time these mistakes would be corrected, and thus progress resumed. From this, Turgot drew the optimistic conclusion, later developed by Condorcet, that progress was an inherent

principle in human history, and that it was destined to continue indefinitely in the future until human society was perfected.

Now the modern sociologist recognizes such a theory of progress to be altogether too simple, and so inadequate from the standpoint of modern science. Nevertheless, there are elements of truth in this eighteenth-century theory which may make it well worthy of further consideration and development by the sociologists of to-day. Both the cultural evolution of the past and the social progress of the future must be considered to be essentially learning processes. They are processes which involve, we shall endeavor to show, the accumulation of knowledge, standards and values and the imparting of these through educative processes to large masses of men in order to control habit and character.

Let us note to what degree this has been true of past social evolution. Human culture would have been impossible if man were not an animal with a prolonged period of immaturity, that is, with a prolonged plasticity which has enabled each individual to be modified in accordance with the requirements of the life of his group. But this is only saying that human civilization would have been impossible without the educability of the individual. The simplest beginnings of those higher adjustments which we call "culture," and which distinguish the social life of man from that of brutes, are not possible till knowledge and skill can be transmitted from one individual to another. Bit by bit the groups of primitive men acquired knowledge and skill and then transmitted them to succeeding generations by educative processes. This process of transmission is often represented as more unconscious and natural, as less artificial and formal, than we have a right to believe that it really was. For the most primitive groups which have survived to-day give instruction to their children in the making of tools, weapons and in other technological processes, as well as in moral and religious matters. Usually, indeed, skill along these several lines is kept up in a succession of individuals or of families who specialize in these directions. The continuity of human culture from the start, therefore, was maintained largely by educative processes, more or less deliberately undertaken as a means of preserving knowledge and habits which groups found to be of value.

In transmitting the knowledge, standards and values upon which their culture rested, primitive groups had, of course, no such formal institution as the school, although they did make use, to some extent, of formal ceremonies, such as initiation

rites and the like. But for the most part, the basic elements in their culture were imparted by the two primary human groups, the family and the horde, or the neighborhood group. These two groups have indeed been the chief bearers of cultural traditions in all ages. They are still the chief agencies for social education. The education which they impart is by no means to be thought of as like the habituation of the individual to his physical environment. On the contrary, there is constant pressure on the child, in both the family and neighborhood groups, whether in savagery or in civilization, to make him conform his habits, his ways of thinking and of acting, to those of his group. The process is really an educational one, though the methods are not so formal as those employed in the school. But there is the constant artificial control of the formation of habit and character, which, as we have already said, is the distinguishing mark of the educative process.

If continuity in social development was secured in human groups from the start largely by educative processes, it is no less true that changes have always been brought about also largely through such processes. The most significant changes for the better in human society have been undoubtedly due to the processes of invention and discovery. Conditions in the environment have been the stimuli for these inventions and discoveries, but the inventions and discoveries themselves must be considered the real means by which civilization has developed. Now, inventions and discoveries are notoriously the work of a relatively few individuals in human groups, and their utilization by the whole group is brought about by the other members of the group being taught how to make use of them. From the simplest stone implement to the latest automobile, most men have had to learn how to utilize or copy the inventions of the exceptional mind. The whole process of generalizing the use of an invention is, therefore, a process of education. But this is true, not merely in the material realm, but also in the realm of human relationships. New modes of associating and cooperating are invented as well as new tools and machines. Forms of government, law, magic and religion are also, more or less, matters of invention. They have to be diffused also through educative processes, and this is largely the significance of many of the ceremonial usages which attach themselves to those institutions.

A high degree of conscious purpose must not, of course, be attributed to those educative methods which are made use of to spread and perpetuate in social groups new inventions and dis-

coveries, whether these be in the technological or in the more strictly social realm. In the case of those mass adjustments which are made by the group as a whole, however, a higher degree of consciousness enters. Collective conscious changes are made in human groups largely through processes of intercommunication, discussion of ideas and the formation of group opinion. All of this may be justly characterized as a sort of reciprocal educative process conducted by the members of the group among one another. Discussion results in the group gradually discriminating the various factors involved in a situation, in an evaluation of those factors, and in the selection of some of them as a basis for a new adjustment. Social discussion, in other words, is largely a mutually educative process for a group. It brings forth, as Bagehot insisted, the best intelligence of the group and centers it upon the solution of the difficulty. In this way a group opinion is reached, that is, a more or less rational judgment which all the members of the group come to accept whether it represents their individual judgment or not. The power of the pressure of such a group opinion is a commonplace in all reflection upon social matters, and it is obvious that it also acts upon the individual in essentially an educational way.

Thus, it is evident that social evolution in the past, so far as it has been brought in any degree under conscious control, has proceeded essentially by the method of education, and that there is good ground for agreement with the dictum of Thomas Davidson that education is the last and highest method of social evolution. Formal education, the school, is simply the attempt to give this method the highest degree of intelligent direction and control. The formation and preservation of a social tradition, the development of what we call "the social mind" and "social consciousness," all imply educative processes. Civilization itself is the production, transmission and diffusion of the knowledge, standards and values by which men have learned to regulate their conduct. These can not be handed down from generation to generation without educational processes to preserve and transmit them; neither can they be greatly modified or changed for the better without such processes. All the generations of men have been accumulating the results of tested experience. Each succeeding generation has been able to do a little more than its predecessors because it has learned all that has resulted from the experience of the past and it is usually able to add a little to the store of tested experience. If conservation of past knowledge and values in

human society were perfect, it is true, as Paley said, that all the generations of men would be like one man ever learning.[1]

It follows that it is the greater or less degree of failure of the educative process which is the immediate cause of periods of moral and intellectual decadence in human society. The failure of the educative process means the failure of the individuals to get proper adjustment to the social life. In every case disintegrative social processes are rooted in the failure to control habits, and so mental and moral character, in individuals. Of course, back of the failure of the educative process to socialize the individual always lie certain general conditions in society which may be regarded as the remoter causes of social disintegration. These are usually social disturbances, such as war, class strife and the development of luxury. War and class strife directly interfere with the educative process, since they divert the energy of the social group to the socially non-productive uses of conflict; while luxury undermines the educative process through relaxing social standards. The failure of the school in the higher phases of civilization to socialize the individual becomes an especially serious matter, since on account of the complexity of social conditions the education afforded by the primary social groups, the family and the neighborhood, is usually quite inadequate. In the higher phases of social life the work of differentiated and specialized educational institutions, therefore, becomes of supreme importance for progressive social evolution.

It is evident that the educative process lies at the heart of cultural evolution and so of human social development. It has been the means by which the civilization of the past has developed. It must be our main reliance for social progress in the future. Those who put faith in other means of social progress, such as revolutions, are destined to be grievously disappointed. Revolutions have swept away obstacles to social progress, but they have never succeeded in effecting permanent progress except as they have been preceded or followed by processes of education. It was the great merit of the late Professor Lester F. Ward that he demonstrated once for all that education is the initial means, and must remain our main reliance, for progress in human society.[2] Ward saw clearly that the social life of man is of the nature of a developing

[1] The part played by educative processes in social continuity and social change will be found more elaborately described in the writer's recent work, "An Introduction to Social Psychology."

[2] See his " Dynamic Sociology," Vol. II., Chaps. X.–XIV.

"social mind"; that to control action, we must control opinions, beliefs, ideas and standards. Ward's conception of education, was, to be sure, narrow. He believed that the diffusion of information would in itself suffice to give rise to dynamic opinions, ideas and actions; so that social progress would automatically result from the diffusion of knowledge. But we now see that while "knowledge is power," it is a power that may be used in many different ways; and that only as it is socially directed will progress result from it. Hence, a more socialized conception of education is necessary, to see clearly its power as a factor in progress, than that which Ward gave.

If we accept, however, the broader and more socialized definition of education worked out by scientific educationists, namely, that education is the artificial control of the formation of habits and character in the individual in order to fit him to participate efficiently in the social life, then we may cordially agree with Ward that the key to progress lies in education. For progress is determined by the psychic adjustment of individuals to the social life, by the "social attitudes" which they maintain toward one another. Now, the psychic adjustment of the individual to the social life, in so far as it is not a matter of heredity—and we have already seen that there is little warrant for believing that heredity furnishes anything more than normal human powers and capacities—is obviously a result of his environment. We must have a properly controlled environment for the individual to develop in, therefore, if we wish to develop in him desirable social attitudes. If properly carried out, personal education should furnish to the developing individual such a properly controlled environment; and inasmuch as it furnishes such an environment at the plastic period of life, it is the most subtle and effective form of social control that can be devised. It can secure more difficult forms of social adjustment than can any other human agency. We mean by a properly controlled environment, of course, not simply a physical environment, but even more, a psychic environment of proper ideas, ideals, standards and values. Even the most civilized nations of the earth have only just begun to use education in this sense, as an instrument of social progress. Let us see what it might do if radically carried out.

In the first place, it could make a normal individual many times more efficient socially than he is at the present time. It could not only give him information, knowledge and skill which would make him a useful member of society in general and fit him for vocational excellence in some line for which he is found

by his nature to be best fitted, but it could give him an entirely different attitude toward the institutions and agencies by which social order is maintained and social life carried on. It could give him, for example, a positive and social view of his government, so that he would not look upon it as a mere repressive agency designed to curtail his individual liberty. It could give him a more constructive attitude toward the family, the school and the neighborhood, so that he would more readily cooperate with others in seeking to bring about conditions favorable to social welfare. If the negative attitude of the individual toward such social institutions, which is perhaps prompted largely by his native egoism, could be overcome, that alone would make greatly toward increased social efficiency and progress.

In the second place, such an education could make much more harmonious the relations between individuals. It is just at this point, perhaps, that the education of the nineteenth century failed most completely. This was because it was so highly individualistic; it laid much more stress upon individual initiative and success than upon social service. We are now beginning to see that it may be possible for us to secure a higher degree of social service from the individual without sacrificing his individual initiative and success. If we make the individual more efficient in cooperating with his fellows, whether in the family, in the school, in the community, or in the nation at large, we need not thereby be subtracting anything from those personal qualities which make for individual initiative and successful performance of undertakings. Rather, we are thereby simply transforming individual achievement into collective achievement, which is the substance of social progress. It is idle to say that moral education of the most idealistic sort can not be given in the public school. The social values contained in our moral ideals can be as well taught in the public school, if our education is given a social direction, as any other part of the curriculum. That the ideals of justice, brotherhood and the service of mankind can not be taught in our public schools as easily as the ideals of business efficiency, vocational excellence or commercial success is absurd.

The one thing which is evidently needed to make our educational system an instrument of true social progress, is that it should be more thoroughly socialized. Social service must become the watchword of the school. The knowledge and training which it furnishes should be given a social direction. Education is simply an effective means for the social manipulation and control of ideas, standards, values, of habits of think-

ing and of acting; but if all this is not done with a social end in view, it is quite evident that nothing could so easily destroy the social institutions which conserve civilization, and even civilization itself, as education. It is just because education is such a power for either social good or social evil that we must see that it is rightly directed socially. Nor is there any danger that this will fasten a clamp upon individual development. For the measure of socialization is how far an individual's ideas, habits and character contribute to the increased harmony, efficiency and happiness of mankind as a whole; and an individual development in any other direction than this will surely not profit either the individual or his group permanently. Education becomes a stumbling block to social progress, not when it is given a truly social, that is, a humanitarian direction, but when it is made an individualistic, class or group matter; when, in other words, it fails to inculcate social service in the broadest sense of that phrase.

But we are told that education can not change the "mores"; that rather it is the "mores" of a group which determine what education shall be. Such a conclusion, however, is utterly unwarranted from human experience. In all ages, education has been more or less successful in changing the "mores." We need only take a single example for illustration from our own time. The temperance movement in modern society has been essentially an educational movement. Its success in its war against alcohol has been dependent upon more or less scientific instruction, regarding the physiological and social effects of the use of alcoholic beverages, in our public schools. In other words, without any radical changes in external conditions, but simply through the inculcation in the young of standards and habits corresponding to scientific conclusions concerning the effects of alcohol, the most progressive modern societies seem about to sweep away the use, if not of all, at least of the stronger alcohol beverages, in spite of the fact that the "mores" connected with the use of such beverages were defended by privilege and by vested interests. Hundreds of similar illustrations of the social effects of education might easily be cited from the history of civilization.

The peculiarly encouraging thing suggested by this illustration, however, is that such social effects were brought about by *education based upon scientific knowledge*. So too, if we inculcate social ideals regarding government, law, sanitation and morality, for example, upon the basis of scientific knowledge, we may surely expect them to have an equally great social

effect. The trouble with much of the moral and social instruction in our schools in the past is that it has been divorced too much from the facts of our social life. But these facts are now accumulating, becoming scientifically organized and generalized, and there is good reason for believing that by focusing such scientific conclusions upon the minds of a developing generation, we can secure an era of social progress such as the world has hitherto scarcely dreamed of. The scientific program of accumulating and rationalizing knowledge, and then of socially organizing and directing the use of such knowledge, as a basis for furthering social progress, is not a chimerical one.

But several things will have to be done by our public school system before education can become the powerful instrument of social progress which it should be. In the first place, more attention will have to be given to the finding and training of social leaders than has yet been given. Nothing great is accomplished in human society without leadership; and advances in a high civilization depend upon finding and training leaders along many lines. The higher institutions of education should be especially charged with this function. They are making a beginning, to be sure, in western civilization in finding and training leaders along a number of lines; but the general field of social leadership they are still largely neglecting. They are producing experts in law and medicine, in agriculture and engineering, but experts in dealing with the larger problems of human living together very rarely; yet these latter are the ones most needed. The superior society of the future, in other words, must be produced just as we are to produce the superior engine. It must be produced by the trained, scientific mind that knows social facts and forces so that it can map out and plan a superior social organization. The superior individual and the superior society are not antitheses, but correlatives. Only our educational system must be brought to realize that social values are not carried by individuals alone or wholly wrapped up in the concept of personality; but that they are also carried by institutional forms and inhere in the larger social life. We must pay attention to the development of the individual and his personality; but we should do so remembering that that development is largely for the sake of society, that is to say the larger life of humanity.

Another thing which will have to be done by our public school system is to effect some sort of coordination between the school and other educational institutions. In the nature of things the school can furnish only a part of the education of

the child. But it should be the center of his education and should set the standard. The home and the church are scarcely less important educational institutions, and some way should be found of coordinating them with the school. In the more specialized phases of education the work of other institutions, such as the farm and the factory, should also be coordinated with that of the school. The school, in brief, needs to come into more vital connection with all other phases of the social life.

Finally, the public school system will have to make larger provision for direct instruction regarding social matters, if it is to become an effective instrument for social progress. Social progress, after all, depends at bottom on awakening and rationalizing social consciousness. The progress of society, even more than the development of the individual, comes through the growth of self-knowledge. Accordingly, our universities should make more provision for research along social lines; and our colleges and secondary schools should give more instruction in the social sciences. We can not have intelligent social service on the part of our citizens without their possessing social knowledge; and indeed they will lack even rational motive for such service without such knowledge. Social progress, then, obviously depends upon the perfecting and diffusion of scientific knowledge of society; and this last depends largely upon our educational system.

These commonplaces of educational and social science show that the general theory of Ward that education is the proximate means of social progress is sound; and that the view of those eighteenth-century social philosophers who held that education is the method of social advance is much more nearly correct than some views which have had vogue during the last few decades. After this war, it is to be hoped that we shall take up the work of socializing our system of education in earnest, as the sure foundation upon which we can build a worthy civilization for the future. For civilization is only just beginning. The work for rational and scientifically planned social progress lies all ahead. And socialized education is the key to such progress.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS[1]

By Professor FREDERICK SODDY, M.A., F.R.S.

THE elements of the chemist are now known to be complex in three different senses. In the first sense the complexity is one that concerns the general nature of matter, and therefore of all the elements in common to greater or less degree. It follows from the relations between matter and electricity which have developed gradually during the past century as the result of experiments made and theories born within the four walls of this institution. Associated initially with the names of Davy and Faraday, they have only in these days come to full fruition as the result of the very brilliant elucidation of the real nature of electricity by your distinguished professor of physics, Sir Joseph Thomson. Such an advance, developing slowly and fitfully, with long intervals of apparent stagnation, needs to be reviewed from generation to generation, disentangled from the undergrowth that obscures it, and its clear conclusions driven home. This complexity of the chemical elements is a consequence of the condition that neither free electricity nor free matter can be studied alone, except in very special phenomena. Our experimental knowledge of matter in quantity is necessarily confined to the complex of matter and electricity which constitutes the material world. This applies even to the "free" elements of the chemist, which in reality are no more free then than they are in their compounds. The difference is merely that, whereas in the latter the elements are combined with other elements, in the so-called free state they are combined with electricity. I shall touch but briefly on this first aspect, as in principle it is now fairly well understood. But its consistent and detailed application to the study of chemical character is still lacking.

The second sense in which the elements, or some of them at least, are known now to be complex has, in sharp contrast to the first, developed suddenly and startlingly from the recognition in radioactive changes, of different radio-elements, non-separable by chemical means, now called isotopes. The natural corollary of this is that the chemical element represents rather

[1] Lecture before the Royal Institution of Great Britain.

a type of element, the members of the type being only chemically alike. Alike they are in most of those properties which were studied prior to the last decade of last century and which are due, as we now think, to the outer shells of the atom, so alike that all the criteria, hitherto relied upon by the chemist as being the most infallible and searching, would declare them to be identical. The apparent identity goes even deeper into the region reached by X-ray spectrum analysis which fails to distinguish between them. The difference is found only in that innermost region of all, the nucleus of the atom, of which radioactive phenomena first made us aware.

But, though these phenomena pointed the way, and easily showed to be different what the chemist and spectroscopist would have decided to be identical, it did more. It showed that although the finer and newer criteria, relied upon by the chemist in his analysis of matter, must of necessity fail in these cases, being ultimately electrical in character, yet the difference should be obvious in that most studied and distinctive characteristic of all—the criterion by which Dalton first distinguished the different kinds of atoms—the atomic weight. Those who have devoted themselves to the exact determination of these weights have now confirmed the difference in two separate cases, which, in absence of what perhaps they might regard as "preconceived notions," they were unable to discover for themselves. This is the experimental development to which I wish more especially to direct your attention. It indicates that the chemical analysis of matter is, even within its own province, superficial rather than ultimate, and that there are indefinitely more distinct elements than the ninety-two possible types of element accommodated by the present periodic system.

The third sense in which the elements are known to be complex is that which, in the form of philosophical speculations, has come down to us from the ancients, which inspired the labors of the alchemists of the Middle Ages, and which in the form of Prout's hypothesis has reappeared in scientific chemistry. It is the sense that denies to nature the right to be complex, and from the earliest times, faith outstripping knowledge, has underlain the belief that all the elements must be built up of the same primordial stuff. The facts of radioactive phenomena have shown that all the radio-elements are indeed made up of lead and helium, and this has definitely removed the question from the region of pure speculation. We know that helium is certainly a material constituent of the elements in the Proutian sense, and it would be harmless, if probably fruit-

less, to anticipate the day of fuller knowledge by atom building and unbuilding on paper. Apart altogether from this, however, the existence of isotopes, the generalization concerning the Periodic Law that has arisen from the study of radioactive change on the one hand and the spectra of X-rays on the other, and experiments on the scattering of α-particles by matter, do give us for the first time a definite conception as to what constitutes the difference between one element and another. We can say how gold would result from lead or mercury, even though the control of the processes necessary to effect the change still eludes us. The nuclear atom proposed by Sir Ernest Rutherford, even though, admittedly, it is only a general and incomplete beginning to a complete theory of atomic structure, enormously simplifies the correlation of a large number of diverse facts. This and what survives of the old electronic theory of matter, in so far as it attempted to explain the periodic law, will therefore be briefly referred to in conclusion.

The Free Element a Compound of Matter and Electricity

Although Davy and Faraday were the contemporaries of Dalton, it must be remembered that it took chemists fifty years to put the atomic theory on a definite and unassailable basis, so that neither of these investigators had the benefit of the very clear view we hold to-day. Davy was the originator of the first electrochemical theory of chemical combination, and Faraday's dictum, "the forces of chemical affinity and electricity are one and the same," it is safe to say, inspires all the modern attempts to reduce chemical character to a science in the sense of something that can be measured quantitatively, as well as expressed qualitatively. Faraday's work on the laws of electrolysis and the discovery that followed from it, when the atomic theory came to be fully developed, that all monovalent atoms or radicles carry the same charge, that divalent atoms carry twice this charge and so on, can be regarded to-day as a simple extension of the law of multiple proportions from compounds between matter and matter to compounds between matter and electricity. Long before the electric charge had been isolated, or the properties of electricity divorced from matter discovered, the same law of multiple proportions which led, without any possibility of escape, to an atomic theory of matter, led, as Helmholtz pointed out in his well-known Faraday lecture to the Chemical Society in this theater in 1881, to an atomic theory of electricity.

The work of Hittorf on the migration of ions, the bold and

upsetting conclusion of Arrhenius that in solution many of the compounds hitherto regarded as most stable exist dissociated into ions, the realization that most of the reactions that take place instantaneously, and are utilized for the identification of elements in chemical analysis, are reactions of ions rather than of the element in question, made very familiar to chemists the enormous difference between the properties of the elements in the charged and in the electrically neutral state.

More slowly appreciated, and not yet perhaps sufficiently emphasized, was the unparalleled intensity of these charges in comparison with anything that electrical science can show, which can be expressed tritely by the statement that the charge on a milligram of hydrogen ions would raise the potential of the world 100,000 volts. Or, if we consider another aspect, and calculate how many free hydrogen ions you could force into a bottle without bursting it, provided, of course, that you could do so without discharging the ions, you would find that, were the bottle of the strongest steel, the breech of a gun, for example, it would burst, by reason of the mutual repulsion of the charges, before as much was put in as would, in the form of hydrogen gas, show the spectrum of the element in a vacuum tube.

Then came the fundamental advances in our knowledge of the nature of electricity, its isolation as the electron, or atom of negative electricity, the great extension of the conception of ions to explain the conduction of electricity through gases, the theoretical reasoning, due in part to Heaviside, that the electron must possess inertia inversely proportional to the diameter of the sphere on which it is concentrated by reason of the electromagnetic principles discovered by Faraday, leading to the all-embracing monism that all mass may be of electro-magnetic origin.

This put the coping-stone to the conclusion that the elements as we apprehend them in ordinary matter are always compounds. In the "free" state they are compounds of the element in multiple atomic proportions with the electron. The ions, which are the real chemically uncombined atoms of matter, can no more exist free in quantity than can the electrons.

The compound may be individual as between the atom and the electron, or it may be statistical, affecting the total number merely of the opposite charges, and the element presumably will be an insulator or conductor of electricity accordingly. Analogously, with compounds, the former condition applies to unionized compounds such as are met with in the domain of

organic chemistry, or ionized, as in the important classes of inorganic compounds, the acids, bases and salts. Just as the chemist has long regarded the union of hydrogen and chlorine as preceded by the decomposition of the hydrogen and chlorine molecule, so he should now further regard the union itself as a decomposition of the hydrogen atom into the positive ion and the negative electron, and a combination of the latter with the chlorine atom.

One of the barriers to the proper understanding and quantitative development of chemical character from this basis is, perhaps, the conventional idea derived from electrostatics, that opposite electric charges neutralize one another. In atomic electricity or chemistry, though the equality of the opposite charges is a necessary condition for existence, there is no such thing as neutralization, or the electrically neutral state. Every atom being the seat of distinct opposite charges, intensely localized, the state of electric neutrality can apply only to a remote point outside it, remote in comparison with its own diameter. We are getting back to the conception of Berzelius, with some possibility of understanding it, that the atom of hydrogen, for example, may be strongly electro-positive, and that of chlorine strongly electro-negative, with regard to one another, and yet each may be electrically neutral in the molar sense. Some day it may be possible to map the electric field surrounding each of the ninety-two possible types of atom, over distances comparable with the atomic diameter. Then the study of chemical character would become a science in Kelvin's sense, of something that could be reduced to a number. But the mathematical conceptions and methods of attack used in electrostatics for macroscopic distances are ill-suited for the purposes of chemistry, which will have to develop methods of its own.

We have to face an apparent paradox that the greater the affinity that binds together the material and electrical constituents of the atom, the less is its combining power in the chemical sense. In other words, the chemical affinity is in inverse ratio to the affinity of matter for electrons. The helium atoms offer a very simple and instructive case. Helium is nonvalent and in the zero family, possessing absolutely no power of chemical combination that can be detected. Yet we know the atom possesses two electrons, for in radioactive change it is expelled without them as the α-particle. The discharge of electricity through it and positive-ray analysis show that the electrons, or certainly one of them, are detachable by electric

agencies, although not by chemical agencies. One would expect helium to act as a diad, forming helides analogous to oxides.

Professor Armstrong for long advocated the view that these inert gases really are endowed with such strong chemical affinities that they are compounds that have never been decomposed. They certainly have such strong affinities for electrons that the atom, the complex of the + ion and electrons, can not be decomposed chemically. Yet, in this case, where the affinity of the matter for the electron is at a maximum, the chemical combining power is absent.

These gases seem to furnish the nearest standard we have to electric neutrality in the atomic sense. The negative charge of the electrons exactly satisfies the positive charge of the matter, and the atomic complex is chemically, because electrically, neutral. In the case of the electro-positive elements, hydrogen and the alkali-metals, one electron more than satisfies the positive charge on the ion, and so long as the equality of opposite charges is not altered, the electron tries to get away. In the case of the electro-negative elements, such as the halogens, the negative charge, though equal presumably to the positive, is not sufficient to neutralize the atom. Hence these groups show strong mutual affinity, one having more and the other less negative electricity than would make the system atomically neutral like helium. The electron explains well the merely numerical aspect of valency. But chemical combining power itself seems to require the idea that equal and opposite charges in the atomic sense are only exactly equivalent in the case of the inert gases. None of these ideas are now new, but their consistent application to the study of chemical compounds seems curiously to hang fire, as though something were still lacking.

It is so difficult for the chemist consistently to realize that chemical affinity is due to a dissociating as well as to a combining tendency and is a differential effect. There is only one affinity, probably, and it is the same as that between oppositely charged spheres. But, atomic charges being enormous and the distances over which they operate in chemical phenomena being minute, this affinity is colossal, even in comparison with chemical standards. What the chemist recognizes as affinity is due to relatively slight differences between the magnitude of the universal tendency of the electron to combine with matter in the case of the different atoms. Over all is the necessary condition that the opposite charges should be equivalent, but this

being satisfied, the individual atoms display the tendencies inherent in their structure, some to lose, others to gain electrons, in order, as we believe from Sir Joseph Thomson's teaching, to accommodate the number of electrons in the outermost ring to some definite number. Chemical affinity needs that some shall lose as well as others gain. Chemical union is always preceded by a dissociation. The tendency to combine, only, is specific to any particular atom, but the energy and driving power of combination is the universal attraction of the + for the — change, of matter for the electron.

The Electrical Theory of Matter

Another barrier that undoubtedly exists to the better appreciation of the modern point of view, even among those most willing to learn, is the confusion that exists between the earlier and the present attempt to explain the relation between matter and electricity. We know negative electricity apart from matter as the electron. We know positive electricity apart from the electron, the hydrogen ion and the radiant helium atom or α-particle of radioactive change for example, and it *is* matter in the free or electrically uncombined condition. Indeed, if you want to find matter free and uncombined, the simple elementary particle of matter in the sense of complexity being discussed, you will go, paradoxically, to what the chemist terms a compound rather than to that which he terms the free element. If this compound is ionized completely it constitutes the nearest approach to matter in the free state. Thus all acids owe their common acidic quality to really free hydrogen, the hydrogen ion, a particle more different from the hydrogen atom than the atom is from the hydrogen molecule.

Positive electricity is thus emphatically not the mere absence of electricity, and any electrical theory of matter purporting to explain matter in terms of electricity does so by the palpable sophistry of calling two fundamentally different things by the same name. The dualism remains whether you speak of matter and electricity, or of positive and negative electricity, and the chemist would do well to stick to his conception of matter, until the physicist has got a new name for positive electricity which will not confuse it with the only kind of electricity that can exist apart from matter.

On the other hand, the theory of the electro-magnetic origin of mass or inertia is a true monism. It tries to explain consistently two things—the inertia of the electron and the inertia of matter—by the same cause. The inertia of the

former being accounted for by the well-known electro-magnetic principles of Faraday, by the assumption that the charge on the electron is concentrated into a sphere of appropriate radius; the 2,000-fold greater inertia of the hydrogen ion, for example, can be accounted for by shrinking the sphere to one two-thousandth of the electronic radius.

But the electrical dualism remains completely unexplained. Call the electron *E* and the hydrogen ion *H*. The facts are that two *E*'s repel one another with the same force and according to the same law as two *H*'s repel each other, or as an *H* attracts an *E*. These very remarkable properties of *H* and *E* are not explained by the explanation of the inertia. Are *E* and *H* made up of the same stuff or of two different stuffs? We do not know, and certainly have no good reason to assume, that matter minus its electrons is made of the same thing as the electron. We have still to reckon with two different things.

The Chemical Elements not necessarily Homogeneous

I pass now to the second and most novel sense in which the elements, or some of them at least, are complex. In their discovery of new radioactive elements, M. and Mme. Curie used radioactivity as a method of chemical analysis precisely as Bunsen and Kirchoff, and later Sir William Crookes, used spectrum analysis to discover caesium and rubidium, and thallium. The new method yielded at once, from uranium minerals, three new radio-elements, radium, polonium and actinium. According to the theory of Sir Ernest Rutherford and myself, these elements are intermediate members in a long sequence of changes of the parent element uranium. In a mineral the various members of the series must coexist in equilibrium, provided none succeed in escaping from the mineral, in quantities inversely proportional to their respective rates of change, or directly proportional to their periods of average life. Radium changes sufficiently slowly to accumulate in small but ponderable quantity in a uranium mineral, and so it was shown to be a new member of the alkaline-earth family of elements, with atomic weight 226.0, occupying a vacant place in the periodic table. Polonium changes 4,500 times more rapidly, and can only exist to the extent of a few hundredths of a milligram in a ton of uranium mineral. Actinium also, though its life period is still unknown, and very possibly is quite long, is scarce for another reason, that it is not in the main line of disintegration, but in a branch series which claims only a few per cent. of the uranium atoms disintegrating. In spite of this,

polonium and actinium have just as much right to be considered new elements, probably, as radium has. Polonium has great resemblance in chemical character both to bismuth and tellurium, but was separated from the first by Mme. Curie and from the second by Marckwald. In the position it occupies as the last member of the sulphur group, bismuth and tellurium are its neighbors in the periodic table. Actinium resembles the rare-earth elements, and most closely lanthanum, but an enrichment of the proportion of actinium from lanthanum has been effected by Giesel. The smallness of the quantities alone prevents their complete separation in the form of pure compounds as was done for radium.

The three gaseous members, the emanations of radium, actinium and thorium, were put in their proper place in the periodic table almost as soon as radium was, for, being chemically inert gases, their characterization was simple. They are the last members of the argon family, and the fact that there are three of about the same atomic weight was probably the first indication, although not clearly appreciated, that more than one chemical element could occupy the same place in the periodic table.

The extension of the three disintegration series proceeded apace; new members were being continually added, but no other new radio-elements—new, that is, in possessing a new chemical character—were discovered. The four longest-lived to be added, radio-lead or radium-D, as it is now more precisely termed, and ionium in the uranium series, and mesothorium-I and radiothorium in the thorium series, could not be separated from other constituents always present in the minerals, radium-D from lead, ionium and radiothorium from thorium, and mesothorium-I from radium. An appreciable proportion of the radioactivity of a uranium mineral is due to radium-D and its products, and its separation would have been a valuable technical achievement, but, though many attempts have been made, this has never been accomplished, and, we know now, probably never will be.

Seven years ago it was the general opinion in the then comparatively undeveloped knowledge of the chemistry of the radio-elements, that there was nothing especially remarkable in this. The chemist is familiar with many pairs or groups of elements, the separation of which is laborious and difficult, and the radio-chemist had not then fully appreciated the power of radioactive analysis in detecting a very slight change in the proportions of two elements, one or both of which were radioactive. The case

is not at all like that of the rare-earth group of elements, for example, in which the equivalent or atomic weight is used as a guide to the progress of the separation. Here the total difference in the equivalent of the completely separated elements is only a very small percentage of the equivalent, and the separation must already have proceeded a long way before it can be ascertained.

Human nature plays its part in scientific advances, and the chemist is human like the rest. My own views on the matter developed with some speed when, in 1910, I came across a new case of this phenomenon. Trying to find out the chemical character of mesothorium-I, which had been kept secret for technical reasons, I found it to have precisely the same chemical character as radium, a discovery which was made in the same year by Marckwald, and actually first published by him. I delayed my publication some months to complete a very careful fractional crystallization of the barium-radium-mesothorium-I chloride separated from thorianite. Although a great number of fractionations were performed, and the radium was enriched, with regard to the barium, several hundred times, the ratio between the radium and mesothorium-I was, within the very small margin of error possible in careful radioactive measurements, not affected by the process. I felt justified in concluding from this case, and its analogy with the several other similar cases then known, that radium and mesothorium-I were non-separable by chemical processes, and had a chemical character not merely like, but identical. It followed that some of the common elements might similarly be mixtures of chemically identical elements. In the cases cited, the non-separable pairs differ in atomic weight from 2 to 4 units. Hence the lack of any regular numerical relationships between the atomic weights would on this view follow naturally.[2] This idea was elaborated in the Chemical Society's Annual Report on Radioactivity for 1910, in the concluding section summing up the position at that time. This was, I think, the beginning of the conception of different elements identical chemically, which later came to be termed "isotopes," though it is sometimes attributed to K. Fajans, whose valuable contributions to radioactivity had not at that date commenced, and whose first contribution to this subject did not appear till 1913.

In the six or seven years that have elapsed the view has received complete vindication. Really, three distinct lines of advance converged to a common conclusion, and, so far as is

[2] Trans. Chem. Soc., 1911, XCIX., 72.

possible, these may be disentangled. First, there has been the exact chemical characterization from the new point of view of every one of the members of the three disintegration series, with lives over one minute. Secondly, came the sweeping generalizations in the interpretation of the periodic law. Lastly, there has been the first beginnings of our experimental knowledge of atomic structure, which got beyond the electronic constituents and at the material atom itself.

In pursuance of the first, Alexander Fleck, at my request, commenced a careful systematic study of the chemical character of all the radio-elements known of which our knowledge was lacking or imperfect, to see which were and which were not separable from known chemical elements. Seldom can the results of so much long and laborious chemical work be expressed in so few words. Every one, that it was possible to examine, was found to be chemically identical either with some common element or with another of the new radio-elements. Of the more important characterizations, mesothorium-II was found to be non-separable from actinium, radium-A from polonium, the three B-members and radium-D from lead, the three C-members and radium-E from bismuth, actinium-D and thorium-D from thallium. These results naturally took some time to complete, and became known fairly widely to others working in the subject before they were published, through A. S. Russell, an old student, who was then carrying on his investigations in radioactivity in Manchester. Their interpretation constitutes the second line of advance.

Before that is considered, it may first be said that every case of chemical non-separability put forward has stood the test of time, and all the many skilled workers who have pitted their chemical skill against Nature in this quest have merely confirmed it. The evidence at the present day is too numerous and detailed to recount. It comes from sources, such as in the technical extraction of mesothorium from monazite, where one process is repeated a nearly endless number of times; from trials of a very great variety of methods, as, for example, in the investigations on radium-D and lead by Paneth and von Hevesy; it is drawn from totally new methods, as in the beautiful proof by the same authors of the electro-chemical identity of these two isotopes; it is at the basis of the use of radioactive elements as indicators for studying the properties of a common element, isotopic with it, at concentrations too feeble to be otherwise dealt with, and from large numbers of isolated observations, as well as prolonged systematic researches. One

of the finest examples of the latter kind of work, the Austrian researches on ionium, will be dealt with later. The most recent, which appeared last month, is by T. W. Richards and N. F. Hall, who subjected lead from Australian carnotite, containing therefore radium-D, to over a thousand fractional crystallizations in the form of chloride, without appreciably altering the atomic weight or the β-activity. So that it may be safely stated that no one who has ever really tested this conclusion now doubts it, and after all they alone have a right to an opinion.

This statement of the non-separability by chemical methods of pairs or groups of elements suffers perhaps from being in a negative form. It looks too much like a mere negative result, a failure, but in reality it is one of the most sweeping positive generalizations that could be made. Ionium we say is non-separable from thorium, but every chemist knows thorium is readily separated from every other known element. Hence, one now knows every detail of the chemistry of the vast majority of these new radio-elements by proxy, even when their life is to be measured in minutes or seconds, as completely as if they were obtainable, like thorium is, by the ton. The difference it makes can only be appreciated by those who have lived through earlier days, when, in some cases, dealing with the separation of radio-constituents from complex minerals, after every chemical separation one took the separated parts to the electroscope to find out where the desired constituent was.

As the evidence accumulated that we had to deal here with something new and fundamental, the question naturally arose whether the spectrum of isotopes would be the same. The spectrum is known, like the chemical character, to be an electronic rather than mass phenomenon, and it was to be expected that the identity should extend to the spectrum. The question has been tested very thoroughly by A. S. Russell and R. Rossi in this country, and by the Austrian workers at the Radium Institut of Vienna, for ionium and thorium, and by various workers for the various isotopes of lead. No certain difference has been found, and it may be concluded that the spectra of isotopes are identical. This identity probably extends to the X-ray spectra, Rutherford and Andrada having shown that the spectrum of the γ-rays of radium-B is identical with the X-ray spectrum of its isotope, lead.

(To be continued)

THE FIRST HUNDRED YEARS OF THE NEW YORK ACADEMY OF SCIENCES

By Dr. JOHN HENDLEY BARNHART
NEW YORK BOTANICAL GARDEN

THE College of Physicians and Surgeons was the one institution in the city of New York, a hundred years ago, which afforded a stimulus to the study of the natural sciences. This was due to the inspiring influence of a single member of the college faculty, Professor Samuel Latham Mitchill, whose name is not as familiar as it should be to the scientists of to-day. In 1816 he was fifty-two years old. He had studied both medicine and law; had served two terms in the legislature of New York, four terms in Congress, and one in the Senate of the United States. For eight years he had been professor of natural history in the medical college; his personal magnetism had attracted many of the students, and he had awakened in them a more than passing interest in the subjects taught by him. There can be no doubt that it was from Dr. Mitchill that the impetus came for the establishment of a scientific society among the young men who gathered about him, and for this if for nothing else he should be held in loving remembrance on this centennial occasion.

It was in the hall of the College of Physicans and Surgeons, in Barclay Street, on the twenty-ninth day of January, 1817, that a few kindred spirits gathered to consider the establishment of an institution devoted to the study of natural history. Dr. Mitchill occupied the chair. Seven more preliminary meetings were held at the college within a month, and finally, all the arrangements being completed, and a constitution adopted and engrossed, the Lyceum of Natural History held its first formal meeting in the evening of the twenty-fourth day of February, at Harmony Hall, a public house on the southeast corner of Duane and William Streets. The first twenty-one members signed the constitution at this time, and the first officers were elected.

Dr. Mitchill was the president; his nephew, Dr. Caspar Wistar Eddy, was the first vice-president; the second vice-president was Rev. Frederick Christian Schaeffer, the young

pastor of Christ Lutheran Church; Dr. John Wakefield Francis, one of Dr. Mitchill's younger colleagues on the faculty of the medical college, was corresponding secretary; the recording secretary was John Brodhead Beck, then a student of medicine; and the treasurer was Dr. Benjamin P. Kissam, who had received his medical degree the preceding year. It is noteworthy that, of the twenty-one signers of the constitution at this meeting, a majority were students, graduates or members of the faculty of the College of Physicians and Surgeons, and as far as known none but the president was more than twenty-seven years old. Among those added during the next three months, and counted as "original members," were several older men, and some who were in no way connected with the medical college, but of these few were ever active in the affairs of the Lyceum.

For nearly fifteen years, from April, 1817, to September, 1831, the Lyceum enjoyed the hospitality of the Common Council of the city, sharing with other societies, rent free, the use of the "New York Institution," popularly known as the "Old Almshouse," in City Hall Park. Here the Lyceum had rooms for its meetings, and for the preservation and display of its collections; these grew apace, not only by gifts, but by the incorporation of material collected specifically for the "cabinet" by Lyceum members. Dr. Mitchill wrote:

> The members called it the Lyceum, in remembrance of the school founded by that sublime genius, Aristotle, at Athens. Disciples of the "mighty Stagirite," they determined, after his example, to be Peripatetics, and to explore and expound the arcana of nature as they walked.

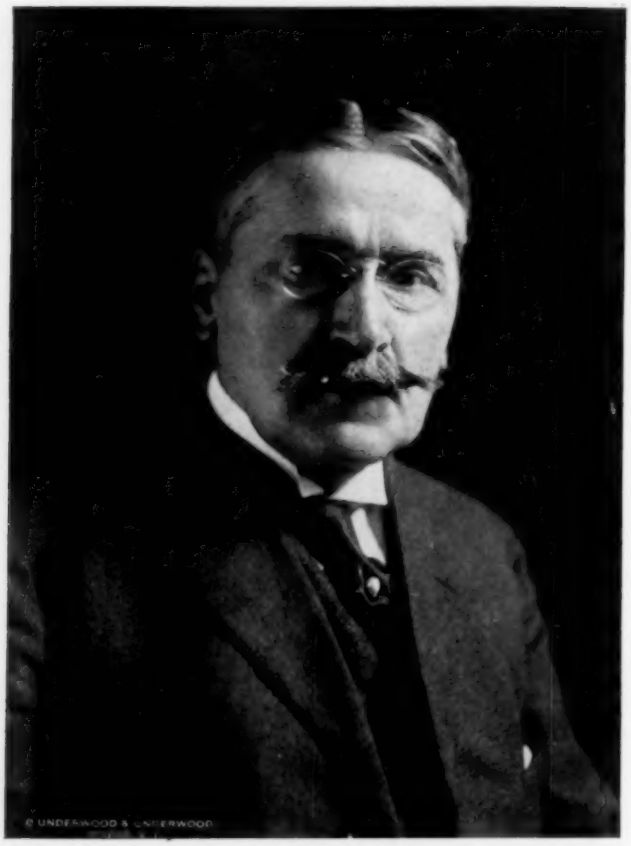
During the first year of the society, 1817, we have mention of collecting trips by Mitchill, Townsend, Torrey, Rafinesque, and Knevels. Within ten years the cabinet of the Lyceum comprised one of the most extensive collections of natural objects in America, excelling all others in its series of minerals, fossils, reptiles, fishes and echinoderms. It is evident that one of the chief purposes of the society from its establishment was the formation of such a museum, and its success was phenomenal.

Soon after the establishment of the Lyceum, the formation of a library was commenced, but this consisted largely of books loaned by members and subsequently withdrawn, so that after an interval of seven years the number of books actually owned by the society was less than two hundred. An old organization known as the United States Military and Philosophical Society, however, having become extinct, with about $2,500 in its treasury, the surviving members transferred this sum to the Lyceum

SAMUEL LATHAM MITCHILL
President of the Lyceum of Natural History, 1817 to 1823.

for use as a library fund. This happened in 1825, and the library then began to grow rapidly and steadily. There are various statistical reports and catalogues recording the number of books at different dates, but it is impossible to use these for comparison, chiefly because of failure to distinguish clearly between the number of volumes and the number of titles.

The first publication of the Lyceum was undoubtedly the printed Constitution, laid on the table at the meeting of May 19, 1817. Technical scientific publication commenced with the issue of the first number of the Annals, in 1823. Two volumes had been completed five years later; these initiated the long series of *Annals*, *Proceedings*, *Transactions*, and *Memoirs*, that have spread the fame of the earlier Lyceum and later Academy throughout the world of science.

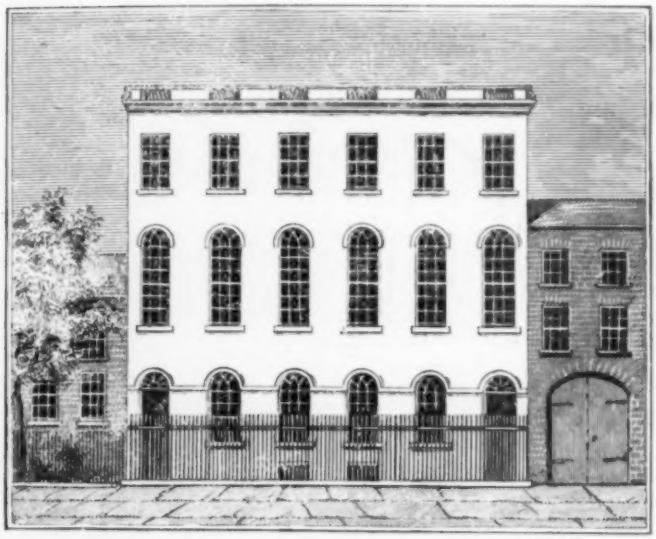


MICHAEL IDVORSKY PUPIN

President of the New York Academy of Sciences, 1916 to 1917.

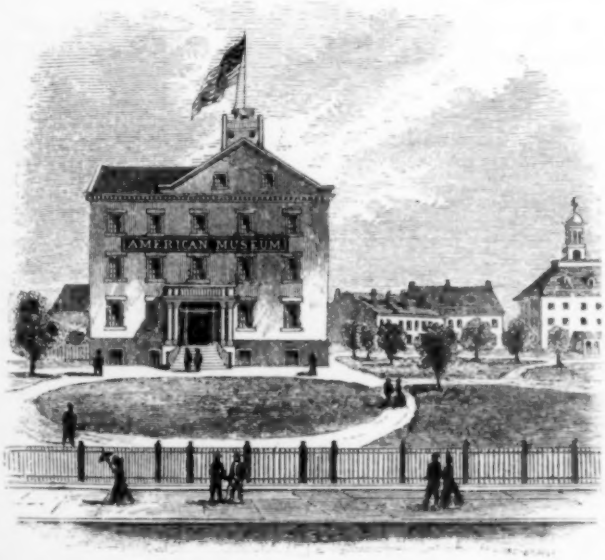
In 1829 the members of the Lyceum learned that they might at any time be required to vacate the four rooms in the New York Institution occupied by them for their meetings, library, and collections, and they began at once to look about for new quarters. A building-fund was inaugurated, but the project had not even reached the stage of selection of a building-site when removal became imperative. The library and collections were temporarily deposited in other rooms in the same building during the winter of 1830–31; the following summer they were removed to new rooms in the New York Dispensary, on the corner of White and Center Streets, and in these rooms the Lyceum met for the first time September 4, 1831.

The Dispensary remained the home of the Lyceum for nearly five years. Meanwhile, the building project was being pushed



COLLEGE OF PHYSICIANS AND SURGEONS, BARCLAY STREET. Where the Lyceum of Natural History was Organized, 1817.

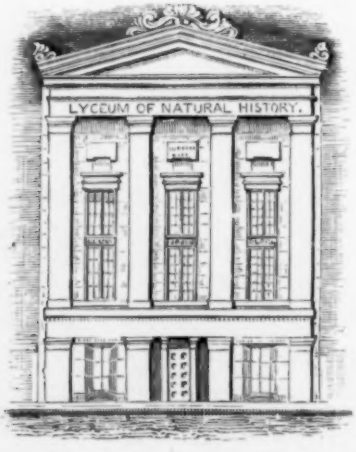
with more energy than caution. In January, 1835, two lots were purchased at 561–565 Broadway, south of Prince Street; construction was commenced in May. A year later, May 9, 1836, the society held its first meeting in its new building.



NEW YORK INSTITUTION, *The "Old Almshouse."*. Western End, Facing Broadway. Home of the Lyceum from 1817 to 1831.

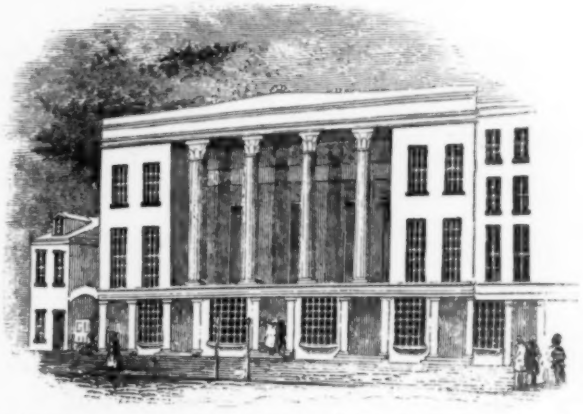
NEW YORK DISPENSARY, WHITE AND CENTRE STREETS. Home of the Lyceum from 1831 to 1836.

There was now ample room for the proper accommodation of the collections and library, and there were stores on the street level and rooms on the upper floors to contribute an income. About fifteen thousand dollars in cash had been invested in the land and building; but this was in a period of financial inflation, and the three mortgages on the property totalled thirty-five thousand dollars. During the years of depression that followed, the financial troubles of the Lyceum went from bad to worse, until finally, in February, 1844, the property was sold at



THE LYCEUM BUILDING, No. 563 BROADWAY. Erected 1835-6; Lost by Foreclosure of Mortgage, 1844.

auction, under legal proceedings, for thirty-seven thousand dollars, barely enough to cover the amount of the mortgages and the unpaid interest thereon. "And the Lyceum found itself out of debt and out of a home, with a valuable library and large collections, and no place to put them." For a year, the collections were stored and the library deposited in the buildings of New York University, while the meetings were held in the home of the president, Major Joseph Delafield, at 104 Franklin Street.



STUYVESANT INSTITUTE, UNIVERSITY MEDICAL COLLEGE. Home of the Lyceum from 1844 to 1851.

After a period of much uncertainty, arrangements were finally completed for rooms with the University Medical College, in Stuyvesant Institute, 659 Broadway, opposite Bond Street. Here the library was satisfactorily accommodated, and a considerable part of the collections could be displayed, and here the Lyceum met for the first time April 7, 1845. In 1851, the medical college sold the building and erected a new one on Fourteenth Street, on the site since long occupied by Tammany Hall. The Lyceum accepted the offer of a meeting-room in the new building, but the collections, with minor exceptions, had to be boxed and stored in the cellar, while the library was deposited temporarily with the Mercantile Library Association.

For fifteen years the Lyceum held its meetings in the Fourteenth Street building, until, on the night of May 21, 1866, this was totally destroyed by fire. The society which had lost its building in 1844 was now without collections; after half a century of enthusiastic work and sacrifice, it was without material possessions other than its library. Well may the members have been discouraged, but they were undismayed; their work went

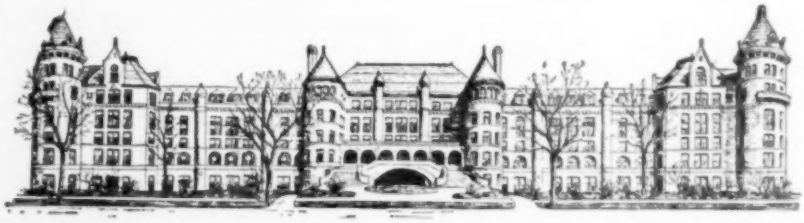
on. For a year the meetings were held in the rooms of the Geographical Society, in Clinton Hall, the same building in which the Lyceum's library had been housed for years.

UNIVERSITY MEDICAL COLLEGE, FOURTEENTH STREET. Erected 1851; Destroyed by Fire, 1866. Home of the Lyceum throughout this Period.

The loss of the collections, as viewed with the perspective of later years, was a blessing in disguise. It relieved the Lyceum of a heavy and ever-increasing burden of responsibility, and paved the way for the establishment of a great independently endowed museum. Such an institution was incorporated three years later, became an actuality within a few more years, and to-day is the scientific center of our great metropolis.

In 1867 the Lyceum removed to Mott Memorial Hall, 64 Madison Avenue; here its library was also installed, and both society and library remained until May, 1878. The semi-centennial of the organization of the Lyceum, in 1867, was allowed to pass by without any formal celebration; but early the following year, April 29, 1868, a public meeting was held in the Great Hall of Cooper Union, in honor of the fiftieth anniversary of the acceptance of the Charter. The historical sketch presented at that time by Professor John Torrey, the only surviving original member, was not preserved.

While the society was located at Mott Memorial Hall, under the presidency of Professor John Strong Newberry, a strong movement sprang up for a change of name. Of course there were many conservative members, particularly those who did not wish to abandon the name with which years of association had linked their affections; but it was urged that the name "Lyceum" had been put to such varied uses that it had lost any appropriateness it might have possessed when originally chosen, that "Natural History" no longer indicated the actual scope of the society's activities, that there was no other organization in New York City devoted to science in general and to science alone, and that the name "The Lyceum of Natural History in the City of New York" was unnecessarily cumbersome. After much discussion, the alteration of the name was approved by the required three-fourths vote; the Supreme Court confirmed the change, and it was accepted by the society February 2, 1876, when the corporate name became The New York Academy of Sciences. At the same time a special class of membership was introduced, called Fellows, "chosen from among the Resident Members in virtue of scientific attainments or services," and most of the detailed routine business of the society was delegated to a central committee called the Council.



AMERICAN MUSEUM OF NATURAL HISTORY. Present Home of the New York Academy of Sciences.

In May, 1878, the Academy deposited its library with the American Museum of Natural History, and changed its meeting-place to the building of the New York Academy of Medicine, then in West Thirty-first Street. Most of the active members of the Academy of Sciences, however, were connected in some way with Columbia College, and the following decade witnessed an increasingly close relationship between the two institutions. Beginning with October, 1883, the meetings of the Academy were held in Hamilton Hall, and three years later the Academy's library was removed from the Museum of Natural History to the Herbarium room in the college library building.

This arrangement continued until Columbia University removed to its present location in 1897.

During the earlier years at Columbia, the Academy held the even tenor of its way, maintaining its dignified position but failing to keep abreast of the rapid development of science in the city. A history of the Academy, by the recording secretary, Mr. H. L. Fairchild, was read in abstract at the meeting of May 10, 1886, and published in full the following May. This handsome volume was not very conveniently arranged for ready reference, and is somewhat unbalanced in the emphasis placed upon the various activities of the society; but it is an invaluable storehouse of reliable information concerning the sixty years of the Lyceum and the first ten of the Academy. One fact, brought out by the inscription on the title-page and the explanation in the preface, is by no means creditable to the Academy, and emphasizes its lack of enterprise at this particular time: the author, after long and faithful labor in the preparation of the manuscript, was permitted to publish the volume at his own expense.

Just how much influence the appearance of this history may have had upon the subsequent development of the Academy is uncertain. It did not call direct attention to the almost moribund condition of the organization, but it did show clearly that the Academy ought to be the leading factor in the scientific life of New York. Such was the wish of those who guided the destinies of the Academy, and they soon began to work diligently with this in view. During the few following years the active membership of the Academy gradually but slowly decreased; this limited the available income, but at the same time resulted in a more compact working body, so that the small membership should not be regarded as a true index to the efficiency of the organization.

The year 1891 witnessed a great forward movement affecting the scientific life of New York. From time to time increasing specialization had resulted in the formation of a number of scientific societies in the city, wholly independent and unrelated except through more or less overlapping of their membership. Organic union of these diverse elements was at no time practicable, yet the desirability of cooperation was self-evident. The first formal suggestion of a plan for such cooperation appears in a communication presented by Dr. N. L. Britton at a meeting of the Council of the Academy held in Room 22, Hamilton Hall, on the afternoon of December 22, 1890. It was a special meeting, called to act upon a revision of the by-

laws; but that revision proved of far less importance than the other matter then discussed. Dr. Britton's communication very concisely outlined the need for concerted action, suggested a method for its accomplishment, and enumerated some of the ways in which the proposed alliance could be of practical value. The plan was referred to a committee, approved, submitted to other scientific societies of the city, and ultimately adopted in agreement with even the minor details of the original communication; and before the close of the summer vacation season of 1891 the Scientific Alliance of New York was fully organized and had entered upon its work. For sixteen years the Alliance was a powerful adjunct of local scientific progress, and paved the way for the Greater Academy of to-day. It issued an annual directory listing the members, and a monthly bulletin announcing the meetings, of all of the component societies. It held two public joint meetings, and in many ways helped to mutualize scientific activities and to bring science prominently before the public. The success of the Alliance was due in large measure to Charles Finney Cox, its first and only president.

One of the primary objects of the Scientific Alliance, the erection of a great building which should serve as a home for all of the societies, and as a scientific center for the city, was never realized. It may yet come; but present opinion seems to favor the strengthening of existing institutions rather than the establishment of new ones. In fact, this sentiment no doubt encouraged the final dissolution of the Alliance, and the adoption of the new plan which grouped the younger organizations of a more specialized nature about the old historic Academy as affiliated societies. The new idea was first promulgated by Mr. William Dutcher, one of the delegates of the Linnæan Society of New York, at the meeting of the Council of the Scientific Alliance held at the Museum of Natural History, January 24, 1906; it met with instant approval, and forthwith was referred to the various societies for action. This was favorable in every case, and the final meeting of the Council of the Alliance was held April 18, 1907; the corporation was then consolidated with that of the New York Academy of Sciences, and the treasurer was instructed to turn over to the Academy all funds of the Alliance.

During the sixteen years of existence of the Scientific Alliance, the work of the Academy had been greatly stimulated. In 1893 there was unveiled in Trinity Cemetery a monument to Audubon, erected by popular subscription through the efforts and under the direction of a committee of the Academy ap-

pointed about five years before. A series of annual receptions and exhibitions to illustrate the recent progress of science was inaugurated in 1894, and repeated in the five succeeding years; these did much to direct the attention of the public both to scientific progress and to the work of the Academy. The organization of sections within the Academy, attempted more or less sporadically in former years, was developed more successfully than ever before.

In 1897, during the summer, Columbia University moved from its old location at Madison Avenue and Forty-ninth Street, to the new site on Morningside Heights. The following winter the Academy held its meetings at Mott Memorial Library, 64 Madison Avenue, while the library remained, practically inaccessible, in the old library building of the University on Forty-ninth Street. The University authorities, utterly regardless of their own interests, refused to allow space in their great new library building for the books of the Academy; they did, however, grudgingly consent to the use of a small room, no. 507, in Schermerhorn Hall. An agreement to this effect was signed in February, 1898; the books, however, were not removed to Schermerhorn Hall until much later in the year, and were then stored in the basement until the following summer. Never, during the four years that the library remained at Columbia after its removal to the new site, was it properly accommodated or reasonably accessible.

For the three seasons of 1898–1901, the Academy held its meetings in the rooms of the American Society of Mechanical Engineers, at 12 West 31st Street; then for one season in the assembly room of the Chemists Club, at 108 West 55th Street. Finally, fifteen years ago, in 1902, the Academy accepted an invitation from the American Museum of Natural History to make this building its permanent meeting-place. In March, 1903, the library of the Academy was brought here to the Museum, where it is properly appreciated, is faithfully and efficiently cared for, and may readily be consulted. In 1904 an office for the use of the Recording Secretary of the Academy was established here, and since that time all of the interests and activities of the Academy have centered in this building.

In 1906, as already mentioned, a proposal came from the Scientific Alliance that the other members of the Alliance should become affiliated with the Academy. This plan was approved by all of the societies concerned; the necessary amendments to the constitution and by-laws were adopted November 5, and the Alliance was wholly merged into the Academy within

the following six months. The past ten years have abundantly confirmed the wisdom of this act. The Academy and its affiliated societies, now seven in number, have enjoyed unprecedented prosperity, and have extended their activities in various directions. Perhaps the most noteworthy events of this decade have been the public celebrations of the bicentenary of the birth of Linnæus and the centenary of the birth of Darwin; the inauguration of a natural history survey of Porto Rico, in cooperation with the government of that island; and the attempt now being made to provide the Academy with adequate endowment.

The effort to condense the history of a hundred years into a brief address has compelled the selection of merely a few of the salient points; no mention has been made even of the names of many who have devoted years of service to the welfare of the Academy. There has been no lack of loyalty; few have ever resigned merely owing to loss of interest. We have now in the Academy fifty whose membership has extended over a quarter of the century; fourteen of these were members in the days of the Lyceum, before the name was altered forty-one years ago, and four have been associated with our history throughout half of its hundred years. The association is continuous, while members come and go, yet upon the exertions of individuals depends the success of the organization. May we of to-day and our successors of the coming years derive inspiration from the honorable record of the past, and emulate the devotion of our predecessors, which we surely never can excel!

THE PROGRESS OF SCIENCE

WORK OF THE NATIONAL RESEARCH COUNCIL

UPON recommendation of the National Research Council Dr. Augustus Trowbridge, of Princeton University, and Professor Theodore Lyman, of Harvard University, have received commissions in the Signal Corps, U. S. A., for work in sound ranging. They have sailed for France to investigate conditions at the front in this subject. The sound ranging service which will be developed under their direction will utilize in the near future more than fifty men. Captain Horatio B. Williams is in charge of the development work in this country during Major Trowbridge's absence.

A meteorological service has been organized under the Signal Corps, U. S. A., in which about one hundred physicists and engineers will be engaged in aerological observational work under the direction of Dr. William H. Blair, of the U. S. Weather Bureau, who has received a commission of major and has sailed for France to investigate conditions abroad. Forecasting work for the American Expeditionary Force in France will be in charge of Mr. E. H. Bowie, of the U. S. Weather Bureau, who has likewise received a commission of major in the Signal Corps and is already on his way to France. Major Bowie will be assisted by Mr. R. Hanson Weightman, of the U. S. Weather Bureau, who has received a commission as lieutenant in the Signal Corps.

Professor Charles E. Mendenhall, of the University of Wisconsin, has received a commission of major in the Signal Corps, U. S. A., and has been placed in charge of the development of aeronautical instruments.

All the work of these services, sound-ranging, meteorology and aernonautical instruments, is included within the scope of the Science and Research Division of the Signal Corps, which in accordance with a recent order of the chief signal officer has been established and placed under the direction of the National Research Council, of which Major R. A. Millikan is the executive officer. The functions of this division of the Signal Corps are twofold, namely: (1) to furnish personnel of the research sort to the other divisions when the situation warrants the assignment of men of this type to these divisions, and (2) to have a personnel of its own which maintains intimate contact with all research and development work in other divisions, and distributes research problems to university, industrial and governmental research laboratories with which it is associated. Similar, though in some cases less formal, relations have been established with other technical bureaus of the War and Navy Departments.

Upon request of the French High Commission a number of American physicists and chemists are being sent to France to assist in various war problems in which technically trained men are needed. Except in certain cases, the Interministerial Commission in Paris will assign them to work in university laboratories and in technical services of the government. Upon recommendation of the National Research Council the following men are receiving commissions in this connection and a number of them have already sailed for France:

Professor R. W. Wood, of Johns Hopkins University, major in the U. S. Signal Corps.

Messrs. Roy W. Chestnut, Leonard Loeb and Samuel Sewall, lieutenants in the U. S. Signal Corps.

Professor Edward Bartow, of the University of Illinois, major, and Professor Reston Stevenson, of the College of the City of New York, captain, in the U. S. Sanitary Corps.

Messrs. Ralph L. Brown, of the University of Chicago, George Scatchard, of Columbia University, and Kirke W. Cushing, of Western Reserve University, lieutenants in the U. S. Sanitary Corps.

FOREST BATTALIONS FOR SERVICE IN FRANCE

THE formation of a second "Forest" regiment comprising ten battalions and composed of lumbermen and woodworkers, who will go to France and get out of the forests materials for the use of the American, French and British armies, has been authorized by the War Department.

Two battalions are to be raised at once with the active aid of the Forest Service of the Department of Agriculture. It is expected that the remaining eight battalions will be called for in a short time. Nine "service" battalions, made up of laborers who will be used in connection with the Forest regiment, have also been authorized and two battalions have been ordered raised at once.

In order to provide for future contingencies it has been decided to commission at the present time enough officers for other battalions yet to be raised. Those men not needed now will be placed on the reserve, and will be called as the other units are formed. According to the present plan, fifty per cent. of the officers will be sawmill and logging operators, twenty-five per cent. will be technical foresters, and twenty-five per cent. will be men with military training who will be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A considerable number of captains and lieutenants are to be selected in the immediate future. The minimum age limit for commissioned officers has been set at thirty-one.

A first regiment of woodsmen numbering about 1,200 men and designated as the Tenth Engineers (Forest) has already been recruited and assembled and is now being trained at American University, D. C. This regiment was raised at the request of the British government to undertake the production in France of crossties, bridge, trench and construction timbers, mine props, lumber, and other forms of wood required in connection with its military operations. The landing of the American expeditionary forces has made necessary similar provision for their needs, while the French military authorities have indicated that some of the work incidental to their operations might be taken over by woodsmen from this country. Decision to raise the new and much larger force has followed a study of the field of possible usefulness to the Allied cause, made by American foresters attached to General Pershing's staff.

Each of the ten battalions of the second regiment will comprise three companies of 250 men each, and will be under the command of its own major. The regiment will be made up of volunteers. Applicants must be white and between the ages of eighteen and forty.

Skilled lumberjacks, portable mill operators, tie cutters, logging teamsters, camp cooks, millwrights and charcoal burners are among the classes of men desired. For the "service" battalions both negro and white laborers will be enlisted.

PHYSIOLOGISTS AND BIOCHEMISTS IN THE NATIONAL SERVICE

THE Surgeon General of the army is organizing a Food Division of his office, the object of which is to safeguard the nutritional interest, of the army by means of competent inspection of food from the standpoint of nutritive value, the supervision of mess conditions, including the economical utilization of food, and a study of the suitability of the army ration for troops in the camp and in the field. Well-trained physiologists and biochemists are needed to direct this work. These men are being commissioned, according to age and experience, as first lieutenants and captains in the Sanitary Corps, Medical Department; or, if they have medical degrees, in the Medical Reserve Corps.

It is probable there will be as many commissioned officers as there are camps and cantonments. Nutritional surveys will be conducted at the camps by surveying parties composed of these commissioned officers, and of drafted men, who have had scientific training, acting as assistants and clerks. It is estimated that such a survey can be completed in from ten days to two weeks for each camp.

It is hoped by means of these surveying parties also to instruct the company mess sergeants and company cooks in improved methods of selecting and preparing the foods. A school for the finished training of the scientists employed in this work is now being organized. The organization of the army, the army methods of handling and cooking foods, the latest methods of food examination and analysis, the conduct of the food survey and kindred topics will be covered by competent instructors from various departments of the army and other departments of the national government.

The facilities of the Bureau of Chemistry, including its analytical laboratories scattered over the country, have been placed at the disposal of the Food Division for this work. Analyses of the garbage will be made and of all foods whose composition is not already known, and the actual distribution of nutrients and of total calories consumed by the men will be computed. Any alteration of the army ration in the future will be based only upon the facts as thus gathered. There is every promise that this service will prove to be of strategic importance in the control of the health and welfare of the troops from the place of their mobilization to the battle front.

THE PSYCHOLOGICAL EXAMINATION OF RECRUITS

AS was announced in SCIENCE at the time, a committee on psychology has been organized, with the approval of the council of the American Psychological Association, by the National Research Council. This committee consists of J. McKeen Cattell, G. Stanley Hall and E. L. Thorndike, from the National Academy of Sciences; Raymond Dodge, S. I. Franz and G. M. Whipple, from the American Psychological Association, and C. E. Seashore, J. B. Watson and R. M. Yerkes, from the American Association for the Advancement of Science. Dr. Yerkes, this year president of the American Psychological Association, lately professor of comparative psychology at Harvard University and recently elected head of the department of psychology at the University of Minnesota, is chairman of the committee, and has been made a major in the Sanitary Corps of the Army in charge of the Section of Psychology, which has been established in the office of the Surgeon General.

A number of committees were organized and are now at work on different problems connected with the conduct of the war and national effi-

ciency, partly under the auspices of the office of the Surgeon General and partly in the office of the Adjutant General. Information concerning the work of the committee on the psychological examination of recruits has been communicated to the press.

The members of that committee are R. M. Yerkes, W. V. Bingham, professor of psychology, Carnegie Institute of Technology, Pittsburgh; H. H. Goddard, director of research, the Training School, Vineland, N. J.; T. H. Haines, professor of medicine, Ohio State University; L. M. Terman, professor of educational psychology, Stanford University; F. L. Wells, psychopathologist, McLean Hospital, Waverley, Mass.; and G. M. Whipple, professor of educational psychology, University of Illinois. This committee met continuously for two weeks planning methods and tests. The seven men then separated, went to various parts of the country and applied the methods in actual practise. After making about 500 examinations they gathered again for two weeks and worked over the methods.

Six weeks after the first gathering of these psychologists, their test sheets, report blanks, etc., were ready for the printer. Arrangements were made for a trial of the method under working conditions with large numbers of men. About 4,000 men in regular organization camps, officers' training camps and naval stations, were examined, and special attention was given to correlating the ratings from the psychological examinations with the ratings prepared by the usual army methods.

The results of these thousands of examinations were sent to Columbia University, where, under the direction of Professor Thorndike and with the cooperation of Professor Cattell, Professor Woodworth and other members of the department of psychology, ten assistants and computers worked a month assembling and analyzing the statistical results. Again the seven psychologists went over their methods in the light of these 4,000 examinations to make further improvements.

The psychological examinations are now in progress in four of the national army cantonments: Camp Devens, at Ayer, Mass.; Camp Dix, at Wrightstown, N. J.; Camp Lee, at Petersburg, Va.; and Camp Taylor, at Louisville, Ky. There are about 160,000 men to be examined in these cantonments, and each will receive an intelligence rating as a result of the psychological examination.

The work is undertaken, first, to supplement the medical examination and second, to give line officers estimates of the mental ability and special aptitudes of their men. Reports of the psychological examinations will be made to the chief surgeon of the camp or the psychiatric officer in order that those mentally incompetent may be considered for discharge, and to the regimental and company officers in order that they may use this additional information concerning their men for the improvement of the service.

OCCUPATIONAL CENSUS OF THE ARMY

THERE is now being made under the direction of the Adjutant General a comprehensive occupational and educational census of the men of the National Army. The object is to carry the selective service law to its logical conclusion and to increase the efficiency of the army by putting the right man in the right place.

With this in view, a personnel organization has been established in each of the 16 cantonments. The previous occupation, education and preference for service of every man are recorded on individual cards,

which are then filed and analyzed at the divisional personnel office in each cantonment. An analysis as to the entire 687,000 men of the first increment can readily be made from these records.

In this work the War Department is having the assistance of a body of civilian experts organized under the name "Committee on classification of personnel in the Army" and including a number of professional employment managers loaned to the government by large industrial and business concerns. The data collected will be used within the divisional organizations to assist division commanders in making the best possible assignment of their men. It will also be of importance in locating men fitted for special branches of the service, such as Aviation, the Ordnance Corps, etc., for which it may be necessary to assign men from the cantonments.

It must not be assumed that men can continue their old occupations in the army. The function of an army is to fight and most of the men, irrespective of previous occupations, will be in the infantry and artillery. Nevertheless, the specialization of modern war requires large numbers of skilled men adapted for technical units and special branches of the service. The locating and placing of such men to the best advantage is of vital importance.

SCIENTIFIC ITEMS

WE record with regret the death of Charles Lee Crandall, emeritus professor of railway engineering and geodesy in Cornell University, and of Lewis Atterbury Stimson, professor of surgery in Cornell Medical College.

THE Surgeon General of the army, Major General William C. Gorgas, has established a board to collect material for the medical and surgical history of American participation in the European War. This board is composed of Colonel C. C. McCulloch, librarian of the Army Medical Library; Major F. H. Garrison, assistant librarian in direct charge of work on the history, and Captain John S. Fulton, secretary of the Maryland State Board of Health, who will have charge of the statistical work.

GOVERNOR JAMES E. FERGUSON, of Texas, has been impeached by the legislature. The charges against him were financial irregularities and improper interference with the board of regents of the state university. The bill providing for the financial support of the university for the next biennium, which was vetoed by Governor Ferguson, has been repassed by the legislature and signed by the acting governor. The professors who were dismissed at the instigation of Governor Ferguson have been reinstated.

DR. JOHN R. MURLIN, for eight years assistant professor of physiology in the medical school of Cornell University, has been appointed director of the new department of vital economics at the University of Rochester. This department is being organized from funds made available by the will of Lewis P. Ross, whose will gave to the university the residuary estate of more than $800,000, the income only to be used "to the end that human life may be prolonged with increased health and happiness." The trustees were instructed to expend that income for two purposes—to contribute toward the support, improvement, and extension of the department of household economics of the Mechanics' Institute of Rochester, and to establish in the university a department of vital economics. Dr. Murlin is now a major in the Sanitary Corps of the national army, and head of the food division in the surgeon general's office.